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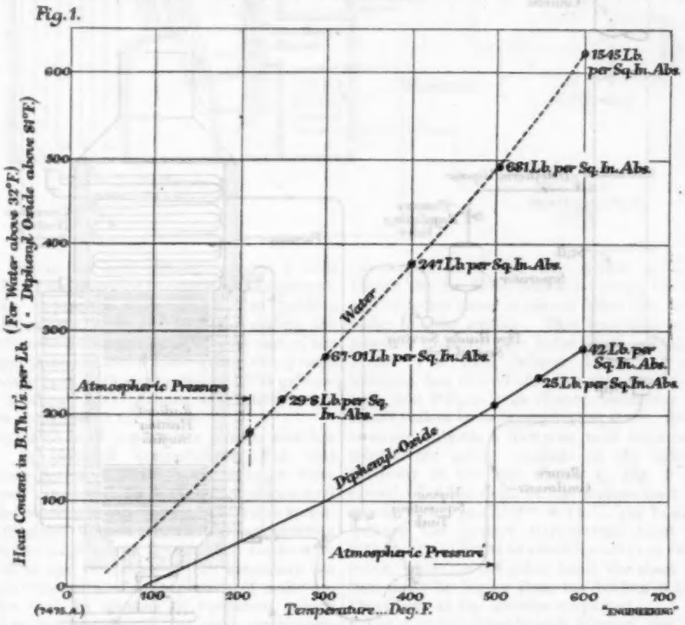
HEAT TRANSFER BY ORGANIC FLUIDS.

By M. HARMAN LEWIS, B.Sc. and D. W. RUDORFF.

IN the field of liquid and gaseous heat carriers, no other medium matches the unique properties of water, which combines high specific heat in the liquid phase with high latent heat in the vapour phase. Where a heat-carrying medium is required for operation at high temperature, however, the pressure-boiling point characteristic of water is a serious drawback, so much so that, in certain cases, it is out of the question to use water or steam as the heat carrier at all. As is shown by the heat-content curve for water in Fig. 1, herewith, a hot-water heat-carrying system, with a supply temperature of 600 deg. F., requires no less than 1,545 lb. per square inch pressure to prevent boiling; and to this pressure a safety margin has still to be added. Apart from the considerable capital outlay entailed by the provision of such high-pressure water-heating (or boiler) plant, the heat exchanger, which in chemical plants often takes the form of a jacketed pan or vessel, would be unduly costly at such a pressure, even if it were not ruled out altogether for technical reasons. The need in such cases for some other kind of heat-carrying agent, either liquid or vaporous, which would obviate the necessity to operate at high pressure, is, therefore, self-evident.

Fig. 1.


1545 Lb. per Sq. In. Abs.
681 Lb. per Sq. In. Abs.
247 Lb. per Sq. In. Abs.
67·01 Lb. per Sq. In. Abs.
42 Lb. per Sq. In. Abs.
29·8 Lb. per Sq. In. Abs.
25 Lb. per Sq. In. Abs.
Water
Diphenyl Oxide
Atmospheric Pressure
Atmospheric Pressure
Heat Content in B.Th.Us. per Lb. (For Water above 32°F.) (For Diphenyl Oxide above 81°F.)
Temperature ... Deg. F.
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Among the various organic or inorganic heat-transfer agents with high boiling point which have been proposed, diphenyl and diphenyl compounds have proved highly suitable, as ten years' practical experience has now shown. Diphenyl has a freezing point of 156 deg. F., and a boiling point of 491·5 deg. F. at atmospheric pressure. Its critical temperature and pressure are about 980 deg. F. and 607 lb. per square inch absolute, respectively. Its latent heat ranges from 120 B.Th.U. to 140 B.Th.U. per pound at the condensation temperatures of practical importance. A disadvantage of this agent is its high boiling point, which makes the provision of special heating devices necessary in order to avoid the danger of freezing. In practical application, therefore, it has been superseded by diphenyloxide, which freezes at 81 deg. F. and boils at 496 deg. F., at atmospheric pressure. As is indicated by its pressure-temperature characteristic, shown in Fig. 1, a pressure of 42 lb. per square inch absolute corresponds to a temperature of 600 deg. F. So far as the pressure-temperature characteristic is concerned, therefore, diphenyloxide is eminently suitable as a heat carrier. Within the range of its practical applicability, the latent heat of diphenyloxide vapour varies from about 140 B.Th.U. to 105 B.Th.U. per pound, while the specific heat of the liquid varies from 0·4 to 0·65, according to temperature. The density of the liquid is 64·6 lb. per cubic foot at 150 deg. F. and 50·9 lb. per cubic foot at 600 deg. F.; while the density of the vapour varies from 0·26 lb. per cubic foot at 496 deg. F. and atmospheric pressure to 0·88 lb. per cubic foot at 600 deg. F. and 42 lb. per square inch pressure. Diphenyl and diphenyloxide are non-corrosive and non-poisonous, so that no special metals need be employed in the construction of the heat-carrier system, neither need any special measures be taken for the protection of the health of the operating personnel, as is necessary with systems operating on mercury vapour.

Of the various other diphenyl compounds developed, Dowtherm A has proved very suitable for general industrial practice. This is a chemical mixture of 73·5 per cent. diphenyloxide and 26·5 per cent. diphenyl. It remains fluid at a temperature as low as 54 deg. F., and thus will not freeze at ordinary room temperature. As the material contracts slightly in freezing, no precautions need be taken to prevent the bursting of pipes where lower temperatures must be reckoned with. The boiling point at atmospheric pressure is at 500 deg. F., while at 600 deg. F. the saturation pressure amounts to 30 lb. per square inch. The chief thermal data of Dowtherm A are plotted in Fig. 2, herewith. Here it is seen that, at a temperature as high as 750 deg. F., the saturation pressure amounts to only 150 lb. per square inch absolute; a temperature which could not be even approximated with saturated steam, as the maximum saturation point of water lies at about 706 deg. F., corresponding to the critical pressure of 3,226 lb. per square inch. A working temperature of 750 deg. F. represents the upper limit for Dowtherm A or other diphenyl compounds. Up to that temperature, Dowtherm A has proved absolutely stable over years of operation. Above 750 deg. F., however, these compounds begin to decompose slowly to other organic compounds, and the periodical purification or replacement which would be required, if operating above the limit of stability, would outweigh the advantages of the material.

With regard to the heat-carrying capacity of diphenyl compounds in the liquid state, Fig. 1 shows that diphenyloxide does not attain to the high capacity of water. This is due to the low specific heat of the material. A comparison on a volumetric basis, however, as given in Fig. 3, on this page, shows that the volume ratio R of diphenyl-oxide and water, representing identical heat quantities, improves considerably at higher temperatures, in favour of diphenyloxide. Thus the ratio R is seen to be above 8·0 at 100 deg. F., while at 600 deg. F. it has fallen to well below 2·0. A similar comparison of Dowtherm A in the vapour phase with steam in the saturated state is given in Table I, below, where the respective latent heat contents of the two materials at various temperatures are given in terms of B.Th.U. per cubic foot. The resultant volume ratio R, based on equal heat contents, is also given in this table, which shows that, with Dowtherm A in the vapour phase, this ratio is considerably greater than that found for the liquid phase. Dowtherm A vapour systems, therefore, require larger pipe sizes than steam systems operating at equal condensing temperature and transmitting equal heat quantities. In view of the low operating pressure of Dowtherm A, the pressure drop in the circuit should be kept as small as possible; but even so, the technical and economic advantage remains with the Dowtherm A system.

Fig. 2.

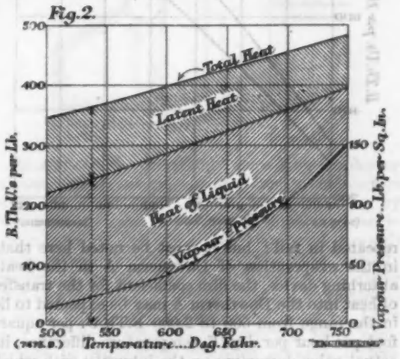
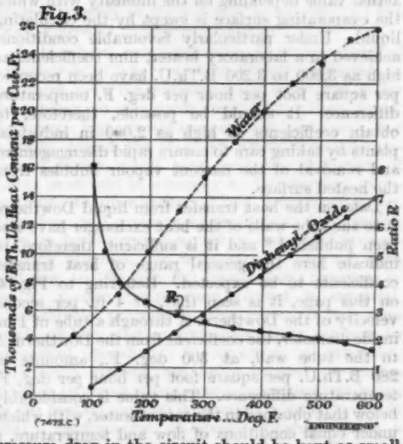


Fig. 3.



For the satisfactory design of a diphenyl-compound heat-carrier system, the various heat-transfer coefficients concerning the transfer of heat from the heating source into the diphenyl compound, as well as those concerning the transfer of heat from the compound into the heat-absorbing part, must, of course, be known. These various coefficients are given in the published study of various tests made on Dowtherm circuits,* and therefore, need not be

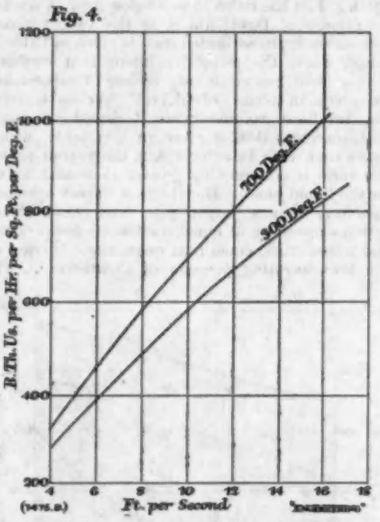
TABLE I.

Condensing Temperature.	Latent Heat Content in B.Th.U. per Cub. Ft.		Ratio R.
	Dowtherm A.	Sat. Steam.	
Deg. F.			
500	34·4	1,058	30·8
520	43·3	1,170	27·0
540	52·0	1,415	27·25
560	62·0	1,870	30·2
580	75·0	1,825	23·3
600	91·8	2,050	22·3

* "Heat Transmission with High Boiling Organic Compounds," by E. F. Holser. *Industrial and Engineering Chemistry*, vol. 28, page 691 (1936).

HEAT TRANSFER BY ORGANIC FLUIDS.

Fig. 4.



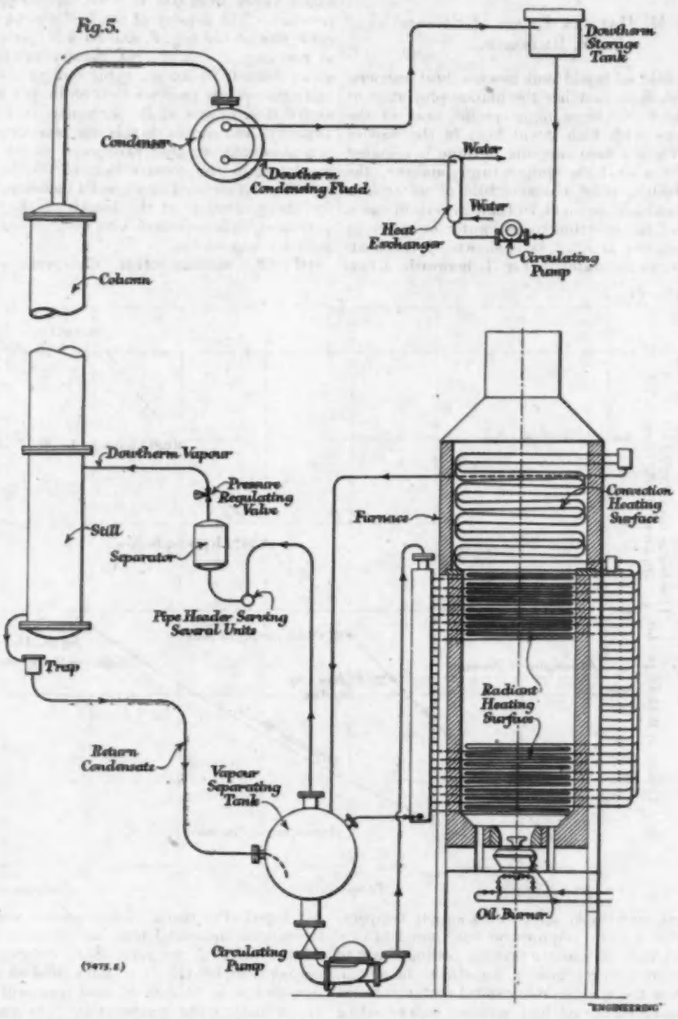
repeated in full; but it must be noted here that, in the evaporation of Dowtherm A in the heat-absorbing device, the film coefficient for the transfer of heat into the Dowtherm A may be expected to lie in the range from 500 to 2,000 B.Th.U. per square foot per hour per deg. F. temperature difference, its actual value depending on the intensity with which the evaporating surface is swept by the circulating liquid. Under particularly favourable conditions, achieved in a laboratory heater, film coefficients as high as 3,000 to 3,200 B.Th.U. have been recorded per square foot per hour per deg. F. temperature difference. It should be possible, therefore, to obtain coefficients as high as 2,000 in industrial plants by taking care to ensure rapid disengagement and removal of the nascent vapour bubbles from the heated surface.

Data on the heat transfer from liquid Dowtherm A to the tube walls of the heat exchanger have also been published,* and it is sufficient, therefore, to indicate here the general range of heat transfer coefficients to be expected. Referring to Fig. 4, on this page, it is seen that, at 4 ft. per second velocity of the Dowtherm A through a tube of 1 in. inside diameter, the coefficient from the Dowtherm A to the tube wall, at 300 deg. F., amounts to 280 B.Th.U. per square foot per hour per deg. F. temperature difference. This value is considerably below that obtained in the case of water, with which, under equal conditions of flow and temperature, a coefficient of approximately 1,900 B.Th.U. is obtained. A correspondingly greater temperature difference is required, therefore, to obtain a heat transfer per unit of surface equal to that with water. Owing to the greater temperature margin available with Dowtherm A, this disadvantage is easily overcome. With regard to the heat transfer from condensing Dowtherm A vapour to the condensation surface, data are also available. In the case of condensation of the vapour upon the outside surface of a horizontal tube of 1 in. outside diameter, the heat-transfer coefficients given in Table II, herewith, have been established. The corresponding coefficient for condensing steam is about 2,000 B.Th.U.

Whether the heat-carrying system is to operate in the vapour phase with condensation or entirely in the liquid phase will depend, of course, on the fundamental requirements applying in a given case. In general, it can be said that heating by condensation is particularly adapted to cases where constant temperature is required, while heating in the liquid phase permits utilisation of the advantages of the counterflow principle in the heat-exchanging device. The latter system is used in the regenerative air-preheating circuit, with diphenyloxide as heat carrier, installed at the Bremo station of the Virginia

* *Loc. cit.*

Fig. 5.



Public Service Company in the United States. This was the first industrial application of the diphenyl heat-carrying system. The two boilers at this plant have each 19,830 sq. ft. of boiler heating surface and each is capable of generating 200,000 lb. of steam per hour at 525 lb. per square inch pressure. They are of the very tall single-pass sectional-header type, with decreasing gas-flow area towards the boiler uptake; a type which attracted considerable attention at the time, but is now practically abandoned. With this type of boiler, the use of an orthodox air preheater, placed on top of the boiler, would have involved a further increase in boiler-house height, besides requiring very long air ducts between the preheater and the air boxes of the pulverised-coal burners. It was decided, therefore, to resort to a diphenyloxide heat-carrier system, designed and built by the Foster Wheeler Corporation of New York. This system is composed of a comparatively small economiser, placed on top of the boiler, and air heaters, connected by a diphenyl-oxide circulating system. In this way, the expensive and bulky air ducts are altogether eliminated.

TABLE II.—*Dowtherm A Vapour.*

Condensing Temperature.	Heat-Transfer Coefficient to Condensing Surface in B.Th.U. per Sq. Ft. per Hour per Deg. F.
Deg. F.	
300	370
400	408
500	420
600	390
700	353

The heat-carrying medium used in this plant is a eutectic mixture of 85 per cent. diphenyloxide with 15 per cent. naphthalene, the freezing point being 63 deg. F. and the boiling point, at atmospheric pressure, 475 deg. F. In the extended-surface economiser of the Foster design, 98,500 lb. of the liquid mixture per hour are heated from 120 deg. F. to 500 deg. F., in counterflow with the flue gases, which enter the economiser at about 630 deg. F. The economiser, built of seamless-steel tubes with shrunk-on cast-iron fins, has a heat absorbing surface of 16,128 sq. ft. The return bends at each end of the straight element tubes are joined to these by welding. The circulating pipes between the economiser and the air heaters are made of 6-in. piping. There are six air heaters; three serve to preheat the primary air, and therefore are arranged near the pulveriser inlets. The other three heaters are placed directly over the burners at the furnace front, and are used for preheating the secondary air. By adjusting the proportion in which the flow of hot diphenyloxide is divided between the primary and secondary preheaters, it is possible to control the drying effect in the pulverisers in accordance with fluctuations in the moisture content of the coal.

The size of the air preheating system can be gauged from the fact that it recovers 16,700,000 B.Th.U. per hour from the flue gases, and transfers this heat with high efficiency to the combustion air. Two 2½-in. cast-steel centrifugal pumps, each of

HEAT TRANSFER BY ORGANIC FLUIDS.

Fig. 6.

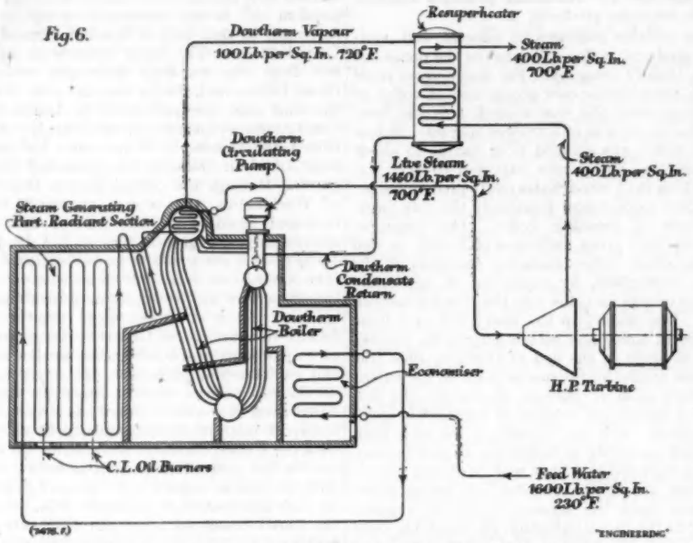
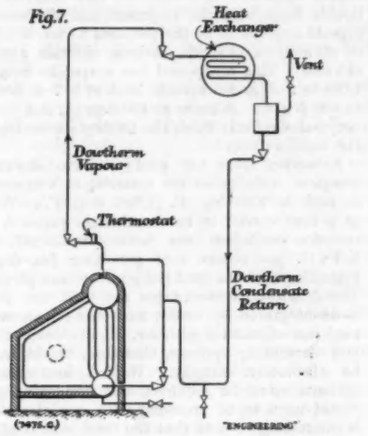


Fig. 7.



200 U.S. gallons per hour capacity against a total head of 270 ft., are provided to circulate the diphenyl-oxide. An expansion tank, capable of holding 1,450 U.S. gallons, with provision for sealing the liquid surface with carbon dioxide, forms part of the system, and there are also a 1,000-gallon dump tank and a storage tank with a capacity of 1,750 gallons. A total of about 2,000 gallons of diphenyloxide mixture is contained in the system.

Diphenyloxide is of low surface tension and low viscosity at elevated temperatures. For this reason some initial troubles with leakages were experienced. Leakage was particularly pronounced in the pump stuffing boxes and also past valve stems. These difficulties were overcome by augmenting the packing of all glands in the circuit. Leaks were also found in the discharge of the secondary air heaters, and necessitated a proportion of make-up, during the first 18 months of operation, which amounted to not less than 30 per cent. per annum. Once these leaks had been stopped, the loss from the system remained steady at about 3·75 per cent., amounting to some 150 U.S. gallons a year for the two boilers. A most important point in the use of such a complex chemical as diphenyloxide is its stability in service. With this in mind, the compound was tested annually for deterioration by decomposition, but no trace could be detected after as long as seven years operation. Inspection of the interior of the pipes and coils of the circuit likewise failed to reveal any sign of corrosion or scaling. It is interesting to note that the power consumption of the circulating pump represents an annual expenditure of only some 60*l.*, while the total cost of operation and maintenance of the systems for the two 200,000-lb. per hour boilers averages 175*l.* per annum.

The first Dowtherm unit to operate in the vapour phase, with the heat-receiving apparatus functioning as a condenser, was installed at the plant of the Dow Chemical Company at Midland, Michigan, U.S.A. The flow circuit of this oil-fired unit is outlined in Fig. 5, opposite. This unit is designed for a normal operating pressure of 30 lb. per square inch absolute with Dowtherm A, corresponding to a saturation temperature of 560 deg. F., but occasionally pressures as high as 50 lb. per square inch are carried. The heat output amounts usually to 1,000,000 B.Th.U. per hour, but the generator is designed for a maximum output of 4,500,000 B.Th.U. per hour. As the diagram shows, it is designed to operate on the forced-circulation system, a centrifugal pump forcing the liquid Dowtherm from the collecting tank into the radiant surface and subsequently through the convection section. As in the La Mont boiler circuit, the collecting drum is used as a vapour separator. It is fed by gravity with Dowtherm condensate returned from the heat exchangers in which the vapour is condensed. Unlike the La Mont boiler, however, the separator and collector drum is placed below the level of the boiler heating surface. This was done to make it possible to drain the boiler coils quickly in the event of a tube failure. Prolonged operation, however, has proved that this safeguard is unnecessary, and designs more closely resembling orthodox steam boilers have been adopted since. Even these, however, include a dumping tank large enough to receive the entire contents of the circuit. The efficiency of the unit shown in Fig. 5 does not exceed 63·5 per cent. at the highest load at which it was tested (4,432,000 B.Th.U. per hour output) because the furnace temperature must be kept within certain limits to avoid burning out the furnace tubes, while, on the other hand, the stack temperature must be higher than the boiling point of the Dowtherm at the pressure employed.

For a time, considerable interest was taken in the possible employment of diphenyl-compound vapours for indirect steam superheating and resuperheating. The feasibility of this has been proved in a high-pressure steam plant operating at the works of the Dow Chemical Company. As is shown by Fig. 6, on this page, the specially-constructed boiler constitutes a combination of a once-through forced-flow steam generator of the coil type with an integral Dowtherm evaporator of the forced-circulation type. Here the steam part comprises a counterflow water economiser, a radiant coil system lining the furnace, and a convection section placed in the outlet from the furnace. The Dowtherm evaporator resembles a bent-tube boiler in which, however, the recirculation between the upper drums is effected by a circulating pump. Superheating of the steam generated at 1,400 lb. per square inch pressure is effected in superheater coils submerged in the topmost drum of the Dowtherm circuit, in which the steam temperature is raised to 700 deg. F. After expansion to 400 lb. per square inch in the high-pressure turbine, the steam is passed into a resuperheater, in which Dowtherm vapour supplied at 100 lb. per square inch and 720 deg. F. serves as heating agent. The steam passes out at 700 deg. F. from this heat exchanger, while the condensed Dowtherm is returned by gravity from the resuperheater shell into the circuit of the Dowtherm vapour generator. The surface areas of the heat-absorbing surfaces installed are as follows: economiser, 13,360 sq. ft.; radiant boiler surface, 3,770 sq. ft.; convection boiler surface, 1,590 sq. ft.; and superheater surface, 2,980 sq. ft., making 21,700 sq. ft. in all. The front bank of the Dowtherm evaporating part contains 4,950 sq. ft. of gas-swept surface, and the rear bank, 4,380 sq. ft. At a steaming rate of 115,000 lb. per hour, a gas temperature of 536 deg. F. at the boiler outlet was observed.

In spite of the complexity caused by employing a secondary vapour-generating system in conjunction with the main steam circuit, re-superheating by this method might have found acceptance, even in central-station practice; but the trend towards high steam-temperature operation has already reached a temperature level considerably above that at which diphenyl compounds can be employed without danger of decomposition. Even so, there may still be a possibility of applying these compounds to multi-stage reheating between turbine stages, possibly in the turbine casing itself, as has been suggested in several proposals.

It has been suggested, also, to apply diphenyl compounds to binary systems of power generation, of which only the mercury-steam cycle has so far been taken up on a commercial scale. Here, again, however, high steam-temperature technique has already passed the stage at which diphenyl-compound cycles would have held the attraction of being next best in economy to the mercury cycle, without its drawbacks. Their main application, therefore, will continue to result from their usefulness as heat-carrying agents in industrial process-heating schemes, for temperatures varying from 400 deg. to 750 deg. F.; particularly processes in which precise temperature control is essential. Considerable progress in this direction has been made of late, and several such plants are now in successful operation. In American oil refineries, Dowtherm systems are being applied to certain refining processes where close temperature regulation of the heating medium is required in order to obtain sharp fractionation of special products with a narrow boiling range. The fact that a heat-carrier of this kind precludes the danger of oil deterioration by overheating is particularly important in the recovery of solvents from lubricating oils. A continuous system of vegetable-oil deodorisation, employing Dowtherm, has been developed recently, to a certain extent superseding the previously employed batch system, also carried out with Dowtherm.

Other important applications are in the distillation of fatty acids, of resins derived from pine, of toll oil derived from the waste liquor obtained in kraft paper production and providing a cheap ingredient in soap production, etc. Among special technical heating processes in which Dowtherm heat-carrier systems should prove of advantage is the melting of tin at the exact temperature required for tinning wires. In the plastics industries, a Dowtherm circuit of the natural-circulation type (such as is shown in Fig. 7, above) for heating kettles was first employed by the Bakelite Corporation in America. The evaporation of high boiling-point solutions, such as caustic soda, constitutes another useful field for the employment of this heat-carrier.

Useful as this heat-carrying agent is in many industries, its comparatively low maximum operating temperature (due to its organic composition) makes it an unsatisfactory medium for storing heat at

high temperature. This problem has occupied the minds of research workers for many years. The closest approach to a solution that will be practicable from both the technical and the economic aspects appears to be the proposal to use a mixture of aluminium chloride, sodium chloride and iron chloride. This compound has a specific weight of 1·96 to 2·0, and a specific heat of 0·7 at 300 deg. to 400 deg. C. It melts at 150 deg. C., and becomes very satisfactorily fluid, the fluidity increasing with the temperature.

Extended tests are said to have shown the complete stability of the material at temperatures as high as 820 deg. C. (1,506 deg. F.). With it as a heat carrier in heat-exchanger pipes, a heat-transfer coefficient has been established of 23 B.Th.U. per square foot per hour per deg. F., indicating that the fluid has poor wetting properties. The greatest disadvantages are that the mixture is disintegrated by water, and that it can only be used out of contact with air. Heat-storage devices and circulating systems, therefore, would have to be absolutely airtight. Welded heat-exchanger systems would be required, and circulating pumps would have to be provided with special seals. It is interesting to note that the total heat content of a cubic foot of this composition, at 400 deg. F., amounts to about 32,200 B.Th.U., whereas the same volume of water at the same temperature, under a pressure exceeding 247 lb. per square inch, has a heat content of about 20,000 B.Th.U. The real usefulness of the composition, of course, would appear at temperatures exceeding those practically obtainable with water. The main difficulties to be overcome in the design of such a heat-storage system appear to be those of ensuring uniform and rapid heat absorption and heat discharge throughout the material.

TRADE AND INDUSTRIES OF BRAZIL.

DEVELOPMENTS in regard to British trade policy with South America are awaiting the report of the official British Trade Mission, under the leadership of Lord Willingdon, which has now returned to London after its tour of the various South American countries. The Mission received an extremely warm welcome in all the countries visited, and there have been many appreciative comments upon the initiative shown by Britain in sending out so important a Mission in the present difficult circumstances. The extent to which this trade drive in South America will succeed depends, reciprocally, upon the scope of Britain's purchases from South America of those primary commodities, stocks of which are increasing to ever higher levels because of the loss of markets on the European Continent following the spread of German occupation there. It is encouraging to learn, therefore, that the Willingdon Mission has closely examined the question of increasing the purchases by Britain of South American export surpluses, which, in turn, would lead to increased buying by South America of manufactured articles from Britain.

Although Britain should obtain a fair share of South American trade on reciprocal lines in the present circumstances, there can be little doubt that, should the European situation persist, South America's exports may be expected to run at low levels, with a consequent lowering of purchasing power, leading to a reduction in imports; it must be remembered that most of the South American countries have effective import control arrangements. There are already many indications of increasing industrial development in South America as a direct result of the present war—as occurred after the Great War—and, should hostilities be prolonged and shipping difficulties be accentuated, this movement, aided by the influx of foreign capital, is likely to be much accelerated and thereby to affect permanently the import trade in many lines of goods. An outstanding development in the industrialisation of South America is the establishment of a national iron and steel plant in Brazil. Before dealing in detail with this project, the present trading background of Brazil may be briefly sketched, particularly in relation to trade with the United States and Great Britain, which are now practically the only two countries supplying South America, as they are also the remaining principal markets for South American products.

Despite notable increases in mineral and agricultural products, coffee still remains the dominant factor in Brazil's economy. For many years there has been considerable over-production of coffee in Brazil, and, since the war started, this has been aggravated by the loss of European markets. Before the war, coffee was shipped from Santos to about forty countries, but is now exported to only six, among which the United States easily predominates; in fact, New York is now practically the only large-scale buyer of Brazilian coffee. The American authorities have given assistance to Brazil, as well as to the other coffee-producing countries of the Western hemisphere, by approving an agreement for import quotas for coffee into the North American market. Due mainly to the heavy fall in volume and value of coffee and cotton shipments, Brazil's balance of trade at the end of October, 1940 (the latest date available) became adverse to the extent of 121,000*l.* (gold); whereas, twelve months previously, a favourable balance of 5,923,000*l.* (gold) was recorded. Although imports, so far, have been maintained (probably in fulfilment of past orders), it is to be expected that they will eventually show a contraction due to the reduced purchasing power consequent upon the present decline in exports.

Owing to the industrialisation of Brazil, the chief imports continue to be machinery, apparatus, tools, etc., the volume of which, in the ten months to October, 1940, was 38,000 tons, valued at 3,967,000*l.* (gold). Imports of other engineering and allied items in the same period (with the comparative figures for the like period of 1939 given in parentheses) were as follows:—Iron and steel manufactures, 173,000 tons (211,000), value 2,351,000*l.* gold (2,455,000*l.*); iron and steel, 88,000 tons (80,000), value 999,000*l.* gold (741,000*l.*); motor-cars, lorries and chassis, 18,843 units (17,046), value 1,526,000*l.* gold (1,459,000*l.*); other vehicles and accessories, 24,000 tons (20,000), value 1,219,000*l.* gold (1,376,000*l.*); coal, coke and patent fuel, 987,000 tons (1,133,000), value 1,480,000*l.* gold (1,179,000*l.*); petrol, 306,000 tons (326,000), value 1,045,000*l.* gold (905,000*l.*); fuel and Diesel oil, 568,000 tons (625,000), value 871,000*l.* gold (663,000*l.*).

The following official figures have also been published of Brazil's principal imports from Great Britain during the first nine months of 1940, the values being expressed in contos of reis (one conto = 12*l.* 10*s.*):—Coal, 182,972 metric tons, value 40,853 contos; patent fuel, 31,642 tons, value 8,370 contos; coke, 11,353 tons, value 5,216 contos; tin, 260 tons, value 5,942 contos; machinery, spare parts, accessories, etc., for textile industries, 1,448 tons, value 20,949 contos; railway trucks, 1,814 tons, value 5,714 contos; motor-car tyres, 625 tons, value 8,134 contos; hoes, 990 tons, value 6,522 contos; copper sulphate, 1,470 tons, value 3,535 contos; white zinc, 1,446 tons, value 3,899 contos; boilers, 445 tons, value 2,753 contos; boiler tubes, 2,746 tons, value 6,962 contos; steam locomotives, value 4,149 contos; locomotive accessories, 649 tons, value 2,280 contos; and tinplates, 1,470 tons, value 4,597 contos.

In regard to the geographical distribution of Brazil's foreign trade with the two principal markets, exports to the United States during the first nine months of 1940 totalled, in gold value, 9,053,000*l.*, against 9,440,000*l.* in the corresponding period of 1939; but those to Britain expanded by 60 per cent., from 2,921,000*l.* to 4,705,000*l.*, which compensated for a similar reduction in the value of exports to the European Continent. Brazil's imports from the United States in the 1940 period, however, expanded in gold value by over 80 per cent., to 12,192,000*l.*, against 6,806,000*l.* in 1939, thereby offsetting a reduction of some 70 per cent. in the value of imports from all European countries, except Great Britain, Portugal, and Spain. Imports of British goods expanded by 8 per cent. in gold value, from 2,282,000 to 2,471,000*l.*

Latin America is strongly pro-Ally and fully appreciates the exigencies of the blockade and other features of Britain's war-time policy, particularly as it is realised that the British Navy is the first bulwark in the defence of the Americas. It is realised that Britain alone cannot deal with the vast problem of South America's mounting export surpluses, so that help is looked for mainly in the United States. The latter country is, of course, free from the war-time difficulties which beset Great Britain and, during the first year of the war, the total value of exports from the United States to Latin America expanded by 42 per cent. and imports from Latin America by 30 per cent. This growth in inter-American trade is being assisted by credits granted through the official Export-Import Bank of Washington, the capital of which has been increased recently by 500 million dols. for the specific purpose of granting credits to Latin America. Little news is yet available as to the ultimate use of this 500 million dols., but it is believed that the largest portion will be employed in revolving credits to carry South American crop surpluses and to finance the purchase of United States goods, as well as on transport and roads in the smaller republics, and on industrial projects in the larger and more developed countries, such as Argentina and Brazil. Apart from new credits, Brazil has already acquired transport material totalling nearly 13 million dols. from the United States on credit terms varying from two to five years, this amount including 5,754,000 dols. for railway engines and wagons, 3,372,000 dols. for rails and materials, 2,275,000 dols. for ships for the Lloyd Brasileiro Line, and 1,331,000 dols. for tankers.

A new large credit by the Export-Import Bank forms an integral part of the financing of the large-scale steel plant in Brazil, preliminary details of which were given in ENGINEERING, vol. 150, page 424 (1940). As then recorded, the total capitalisation of the operating company will be about 45 million dols., it being estimated that the completion of the plant will require nearly three years. Of the capital, 20 million dols. will be forthcoming from the Export-Import Bank of Washington, and the balance of 25 million dols. from official and private sources in Brazil; it is understood that subscriptions for the purpose in Brazil have been forthcoming in a very satisfactory manner. The relative agreement was signed in September, 1940, by representatives of the United States and Brazilian Governments, and, according to New York reports in mid-December, the contract for the design and supervision of construction of the complete plant has now been placed. The cost of the plant alone, it is stated, will be in the neighbourhood of 36 million dols. On January 31, 1941, it was reported in Rio de Janeiro that Dr. Vargas, the President of Brazil, had signed the relative decree forming the Brazilian Steel Company, the plant to be built at Volta Redonda, in the State of Rio de Janeiro, so that it may be presumed that the whole scheme will now make good progress.

The New York report already referred to states that the new Brazilian steelworks is to have a daily capacity of 1,000 tons, with rolling plant for producing a complete list of rolled-steel products, ranging from heavy semi-finished steel rails and structural materials to finished sheets and tinplates. In this connection, it may be noted that the Executive Board of the Brazilian National Siderurgical Plan approved in November last the following programme of annual production to be undertaken at the new works:—Rails and accessories, 90,000 metric tons; shaped steel, 25,000 tons; steel rods, 50,000 tons; steel plates, 60,000 tons; steel ingots, 20,000 tons; tinplate, 50,000 tons; pig-iron, 50,000 tons; foundry coke, 50,000 tons; sulphate of ammonia, 4,000 tons; and light oils, 3,600,000 litres. The development of the iron and steel industry in Brazil on such an extensive scale involves questions of the highest importance relating to the economic future of the country, particularly as it is calculated in Brazil that, once the plant is in full production, the country will be practically self-sufficient as regards supplies of iron and steel products. Even before the present scheme, considerable progress had been registered since 1930, when the question began to be considered seriously. The production of pig iron in Brazil in 1930 was only about 35,000 tons, but it increased by 1939 to 160,116 tons, while, over the same period, the production of steel

rose from 20,985 tons to 114,095 tons, and that of sheet iron from 25,985 tons to 100,996 tons. Even so, Brazil's present production of iron and steel does not meet national needs, so that there are still imported quite considerable quantities of raw iron and steel, as well as manufactured articles. In 1939, Brazil imported 237,352 tons of manufactured iron and steel, compared with the 1913 figure of 578,011 tons. In the latter year, only 79,815 tons of iron and steel were imported as raw material, but this had risen by 1939 to 90,502 tons, notwithstanding that at the present time the national production of iron and steel alone amounts to over 300,000 tons.

Existing Brazilian undertakings producing pig-iron, steel and sheet iron possess 300,000 contos capital, the most important of these companies being the Belgo-Mineira, with 143,597 contos, and the Companhia Brasileira de Usinas Metalúrgicas, with 61,396 contos. In Monlevade, there are also up-to-date installations which make pig-iron for foundry purposes, iron and steel for reinforced-concrete, round, square, flat and angle iron, wire for nails, plain galvanised wire, three-strand wires, machine-wire for twisting into three-strand wire, and barbed wire. Recently, plans have been passed for the installation of plant for the manufacture of rails, and the necessary machinery has already been ordered in the United States. This plant will be capable of producing 50,000 tons annually, or even as much as 80,000 tons.

Brazil already produces ever-increasing quantities of manufactured articles of iron, steel and aluminium. The wire and cutlery industries have grown considerably. Other products increasing in importance are nails; bolts for rails; metal work for buildings, furniture, etc.; agricultural implements; stoves and heaters; electric irons; iron furniture; and enamelled-iron utensils. Progress is also being made in the manufacture of aeroplanes, warships, locomotives and railway wagons. A progressive expansion has also occurred during recent years in the production of electric-light bulbs, electrical apparatus, and batteries, thereby causing imports of these items to decline. Actually, Brazil already exports to neighbouring countries a considerable amount of machinery and apparatus.

The contemplated great expansion in the iron and steel industry will be assisted by the enormous reserves of iron ore, as well as of coal. The iron-ore deposits are mainly in the State of Minas Geraes, situated some 550 km. to 600 km. from the nearest ports, including Rio de Janeiro. It is now understood, however, that the Central of Brazil and Theresa Christina Railways are to be greatly improved with respect to their tracks, fixtures and rolling stock; while, at the same time, steps are being taken to solve the problem of equipping the ports of Rio de Janeiro, Laguna and Imbituba, in order to facilitate the transport of the Brazilian coal which will be used as fuel. The total quantity of coal mined in Brazil from January to June, 1940, was officially recorded at 643,377 metric tons, an increase of 35 per cent. on the figure for the first half of 1939. The Brazilian Minister of Transport recently stated that the production of coal in each of the States of Santa Catharina and Rio Grande do Sul would be increased to 1,000,000 metric tons a year. The output in the former State in 1939 was 204,000 tons, while 841,000 tons were produced in Rio Grande do Sul.

It would appear that the development of the iron and steel industry is not to be confined to Brazil. It is learned from Lima that negotiations are proceeding between the Peruvian Government and the Export-Import Bank with a view to the participation of the latter in a scheme to develop the iron and steel industry in Peru. Large deposits of iron ore are known to exist at Marcona, situated 250 miles South of Lima, and at Chimbote in the North of the Republic. The sum which would be required is stated to approximate 20 million dols. (U.S.).

TIN PRODUCTION IN MALAYA.—The Malayan Information Agency in London announces that the output of tin and of tin ore containing 75·5 per cent. of the metal, in Malaya, was 5,081 tons during February. Of this, the Federated States produced 4,899 tons, the Unfederated States 171 tons, and the Straits Settlements 11 tons.

THE TREATMENT AND TESTING OF RUBBER.

By F. H. COTTON, M.Sc.

RUBBER is a hydrocarbon synthesised by nature in the soft bark of a tropical tree. It is tapped as a milky latex containing 30 per cent. to 40 per cent. of rubber, dispersed like cream in a watery whey. Raw rubber is obtained from the latex by evaporation of the serum, or by coagulation with acid in a process analogous to the separation of curd from milk in cheese-making. A hundred and twenty years ago, Thomas Hancock, father of the British rubber industry, managed to import some liquid latex from Central America in vessels formed of two or three joints of the larger kind of bamboo. He recognised the potentialities of this liquid variety of the native gum and obtained several classic patents for its use in impregnating felt, cordage, ropes, etc. Ten years later, he appointed an agent in Tampico to collect and ship the milk in barrels; but in his attempts at commercial development, Hancock was baffled by the putrefaction of the material. Thereafter, rubber latex remained a scientific curiosity in Europe for a century. Thanks to the discovery of means of preservation, the last two decades have witnessed the reintroduction of latex as a raw material for manufacture, offering immense advantages in such specialised lines as sponge and cellular rubber, elastic thread and rubber-impregnated fabrics.

In the early years of this century, the premier grade of raw rubber was "fine hard para," produced by natives in the jungles of the Amazon valley by drying layer upon layer of latex on wooden paddles revolved over smoky fires of special nuts. The output of this wild rubber was insufficient to meet the growing demand from the young motor-car industry, and in 1909 the price soared to 12*s.* 6*d.* per pound. Fortunately for British interests, the potential value of rubber as a Colonial product had been foreseen by Sir Joseph Hooker, Director of Kew Gardens, nearly 40 years previously; and in 1876 the late Sir Henry Wickham, as the culmination of a daring adventure, managed to smuggle some 70,000 rubber seeds from Brazil. From a few of these, which later germinated in the glass houses of Kew, came the stock subsequently responsible for plantations now covering millions of acres in Malaya, Ceylon and the East Indies.

With the development of the plantation-rubber industry, two standard grades of raw rubber have emerged. Scientifically-collected latex is bulked and subjected to controlled coagulation with dilute formic acid. Most of the soft coagulum, in the form of thick slabs, is gradually pressed by repeated passage through rollers, to squeeze out the serum; after which the rubber is dried and rendered antiseptic by smoking. The resultant product is the brown translucent "smoked sheet" of Mincing-lane. A smaller proportion of the fresh coagulum is kneaded between rolls under flowing water, which removes proteins and other constituents responsible for mould formation. Drying then produces the almost white lacy crepe used in light-coloured rubber mixes.

Despite its remarkable elasticity and wearing properties, rubber would have achieved little commercial importance but for the discovery of three fundamental rubber processes, namely, mastication, vulcanisation, and reinforcement. Raw rubber becomes board-hard in cold weather, and soft and plastic under the influence of heat. Sunlight soon degrades it to a treacly oxidation product. Petrol and oil attack and dissolve it. Contrary to popular belief, raw rubber cannot be melted; therefore, it cannot be cast by a moulding process like that employed for metals. Once liquefied by heat, rubber is partially decomposed and remains as a treacle. The formation of compact masses from the crude material, therefore, constituted a seemingly insoluble problem to the earliest rubber manufacturers. The birth of the industry as now known may be traced to the discovery by Hancock, about 1820, that by powerful kneading and grinding between rollers the "nerve" of the raw material could be broken down and the rubber rendered sufficiently plastic to be mixed with powders, rolled into sheet and moulded by pressure. The present writer was able to show, in 1931, that the softening induced by mastication is really caused by chemical combination with oxygen. Mastication in nitrogen or other inert gas leaves the rubber little affected.

As the outcome of untiring independent experiments in America and this country, Charles Goodyear in 1839, and Thomas Hancock in 1842-43, discovered that, if masticated rubber is mixed with sulphur and heated for several hours at a temperature around 140 deg. C., not only does it regain its original resilience and elasticity in enhanced degree, but the vulcanised product is far less susceptible to changes in temperature, and only swells (without dissolving) in oil and other solvents. The modern tyre, with a useful life of some 50,000 miles, was made possible by a much later discovery that the tensile strength and abrasion resistance of vulcanised rubber can be astonishingly increased by compounding with a special quality of soot produced by burning natural gas, from petroleum wells, in a limited supply of air. The effect is a physico-chemical one, engaging widespread attention. Other fundamental discoveries contributing to the excellence of modern rubber products are organic accelerators, which speed up vulcanisation and greatly improve the physical properties of the cured product; and anti-oxidants, which effectively shield rubber from the early onslaught of its traditional enemy—oxygen.

Early experience showed vulcanisation to be a critical procedure. Under-vulcanisation gave weak products of low elastic modulus; over-cure gave toughness at the cost of brittle shortness. Rubber in both conditions proved to age badly, compared with that properly vulcanised. Slowly it became appreciated that, to get the best results, 3 to 4 parts of sulphur should be caused to combine with every 100 parts of rubber. Following the brilliant contributions of R. Henriques in 1892-4, and of C. O. Weber between that date and 1905, it was perhaps natural that chemical analysis should become the first arbiter of quality in manufactured rubber products. Thus, all early specifications stipulated limits for the chemically-combined sulphur. Chemical analysis was understood, whereas few laboratories were equipped with apparatus for investigating the mechanical properties of rubber. Even the plasticity of the masticated raw material could not be directly ascertained; where laboratory control was essential, the plastic properties were followed by measurements of solution viscosity.

With the advent of organic accelerators, combined sulphur was no longer an index of state of vulcanisation. With fast accelerators, the optimum cure may occur when only $\frac{1}{2}$ per cent. of sulphur has become firmly attached to the rubber. With slow accelerators, however, a vulcanisation coefficient of $\frac{1}{2}$ would barely render the material sufficiently rigid to remove from the mould. To-day, far more reliance is placed upon the results of mechanical tests, before and after ageing of the rubber. The technique of rubber testing is undergoing rapid development.

In formulating British Standards for rubber products, it became apparent that co-ordination of testing procedure would be facilitated by the publication of recommended methods under the ægis of the British Standards Institution. A proposal to that effect having been made by the Research Association of British Rubber Manufacturers, the Rubber Industry Committee and the Chemical Engineering Committee of the Institution co-operated in the compilation of the methods which have now been published in booklet form as B.S. No. 902 and B.S. No. 903 of 1940. The former refers to latex, raw rubber and unvulcanised compounded rubber; the latter, to vulcanised rubber. B.S. No. 902 deals with the sampling of latex, the determination of dry-rubber content, total solids, alkalinity, etc., and the measurement of colour in latex. As regards raw rubber and unvulcanised compounded rubber, it specifies methods of ascertaining the acetone extract, acid value, nitrogen, moisture, total sulphur and various fillers. The determination of plasticity, mastication number, and equilibrium water absorption of raw rubber are also described.

2-6-2 MIXED-TRAFFIC LOCOMOTIVE FOR THE L.N.E.R.

SIR H. NIGEL GRESLEY, C.B.E., CHIEF MECHANICAL ENGINEER.

(For Description, see Opposite Page.)

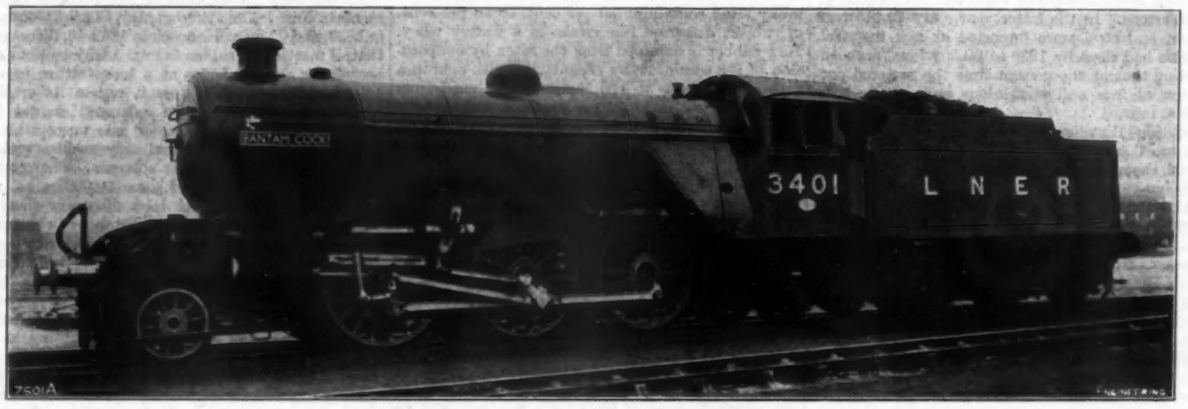
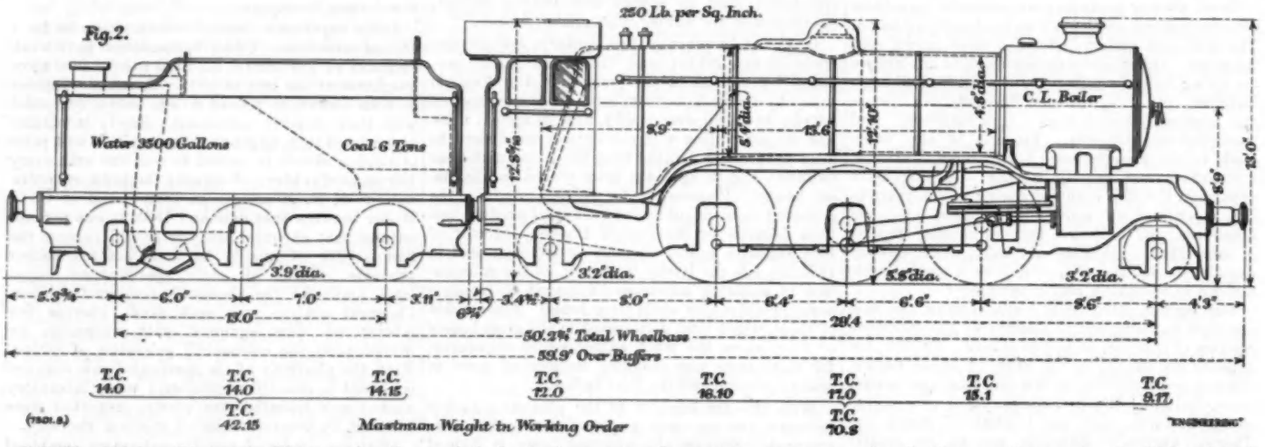


FIG. 1.



B.S. No. 903 is a 74-page booklet covering the chemical analysis and physical testing of vulcanised rubber and ebonite. Detailed procedures are outlined for acetone extraction, the determination of unsaponifiable matter, wax and sulphur in the acetone extract, the extraction with chloroform and alcoholic caustic potash, and the determination of sulphur, carbon black and other fillers. Physical testing methods described include the determination of tensile strength, permanent set, hardness, electrical properties, swelling capacity in solvents, permeability to gases, and methods of accelerated ageing.

The amount of work involved in arriving at such agreed methods is obviously great. They will be invaluable to rubber chemists and technologists throughout the world, and their publication marks a decisive step towards that unification of effort so desired in the rubber industry. At the same time, the issuing Committee states, it "is fully aware of the rapid developments which are taking place in the technique of rubber testing," and it is obvious from the nature of some of the tests prescribed that they are likely to be modified or superseded within a short time. Tests for resilience, abrasion resistance, compression-set and ply-adhesion vary to such an extent from one laboratory to another that their standardisation must constitute a difficult problem. These tests are mentioned as being under consideration for incorporation in a future edition.

In B.S. No. 902, the difficulty of measuring the colour of latex is frankly admitted, and it is stated that, for exact determination, a colorimeter must be used. This view confirms the experience of the present writer, who was led, some years ago, to devise a relatively simple apparatus for exact measurement by a modified photometer method.* It seems unfortunate that the only method described as a British Standard should be one "for determining roughly the greyness of the latex and also its yellowness." This involves the use of a chart containing one substantially white shade, three grey shades and one yellow shade. The surface of the latex sample is to be compared, under prescribed conditions, with this chart. "The chart shall be held horizontally," it is stated, as "an appreciable tilt towards or away from the light considerably affects the apparent colour of the chart shades." Anyone who has tried the method must agree. When it is added that six other distinct precautions must be observed in making the test, its somewhat unsatisfactory nature will be evident.

Divergence of opinion regarding the best ways of testing rubber is reflected on page 19 of B.S. No. 903, where two distinct methods for determining free sulphur are recommended; on page 21, where two methods of decomposing vulcanised rubber prior to extraction of fillers are given; and on page 41, where ring and dumb-bell shaped tensile test pieces are individually approved, although rubber technicians are aware that they give very different results. In fact, the nature of the ring test piece makes it impossible to conform with the requirement mentioned, that the stress shall be "substantially uniform over the cross-section."

In the determination of total sulphur, the instruction is given to heat a mixture of nitrated rubber, sodium nitrate and carbonate "till the mixture is molten." It seems that caution should be advised in thus heating what is virtually a modification of gunpowder. The procedure given for estimating antimony is stated to be "not applicable when iron or chromium is present," but as iron-oxide red may be anticipated in conjunction with crimson or orange antimony sulphides, a method which is not vitiated by the presence of iron would be desirable.

H. A. Curran has criticised* the practice proposed for finding carbon black, maintaining that the Gooch crucible prepared as described, with a layer of kieselguhr on a thin pad of asbestos, does not retain carbon black. He prefers a special filter-bed of asbestos, the formation of which he describes. C. Avons† has found that, if the asbestos pad and its contents are always covered with a small amount of the last wash, the carbon black does not pass through. The whole process of decomposing rubber with nitric acid and separating carbon and other fillers is laborious. Final determination of the carbon by combustion would make the analysis so lengthy that it would seldom be used. J. B. Roberts, Junr.,‡ has advocated that the sample should be digested with hot cresol; followed by dilution with petrol, filtration, washing with solvent, removal of volatile matter by ignition in carbon dioxide, and final estimation of free carbon by weighing, igniting in air and noting loss. An altogether simpler procedure, more in line with that commonly used in the works laboratory, has been evolved by A. Marty.§

* *Trans. Inst. Rubber Ind.*, vol. 11, page 89 (1935).

* *India-Rubber Journal*, vol. 98, page 747 (1939).
† *Ibid.*, vol. 99, page 41 (1940).
‡ *Ibid.*, vol. 100, page 212 (1940).
§ *Rubber Chem. Tech.*, vol. 12, page 609 (1939).

MIXED-TRAFFIC LOCOMOTIVE; LONDON & NORTH EASTERN RLY.

SIR H. NIGEL GRESLEY, C.B.E., CHIEF MECHANICAL ENGINEER,

(*For Description, see Page* 267).

Fig.3.

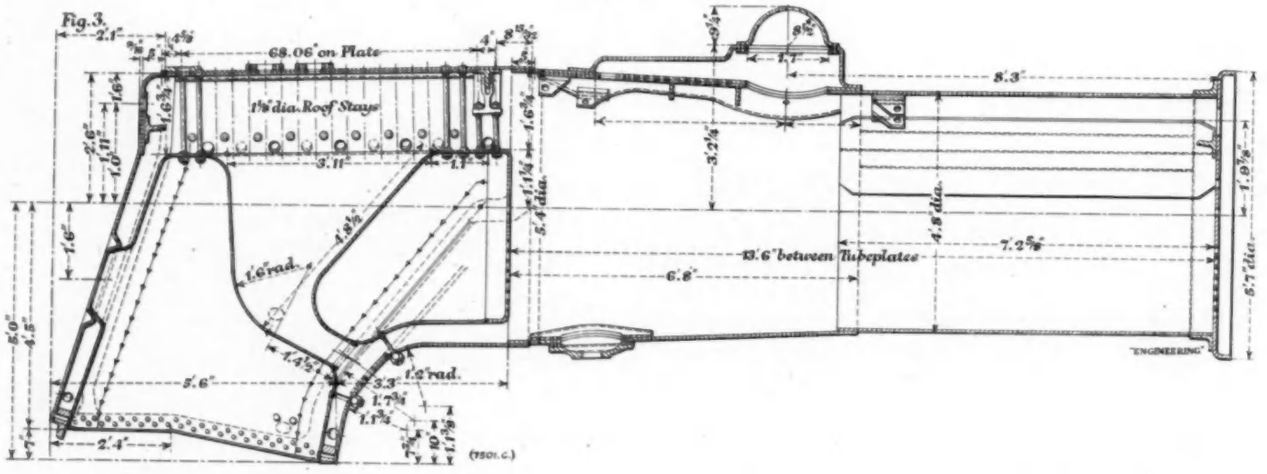


Fig.4.

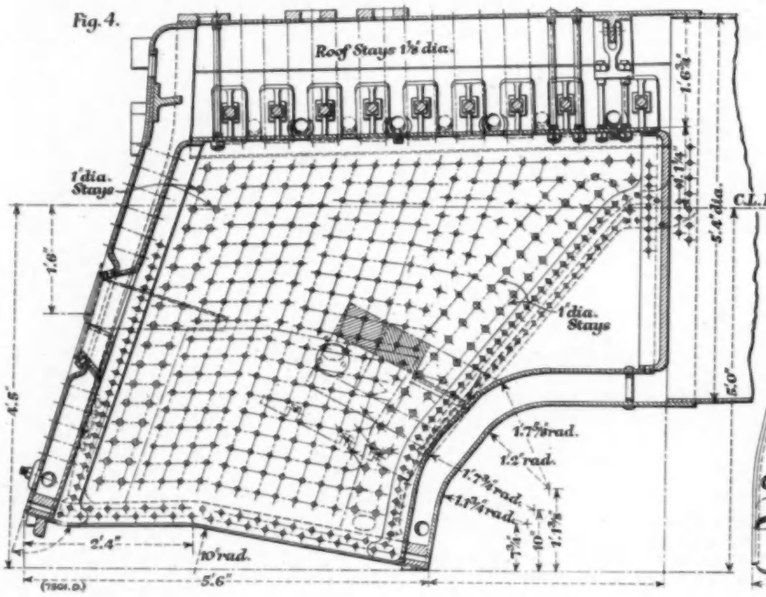


Fig.5.

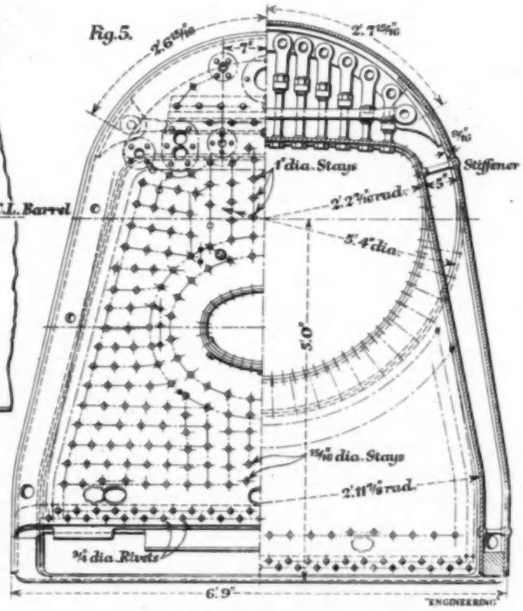


Fig.6.

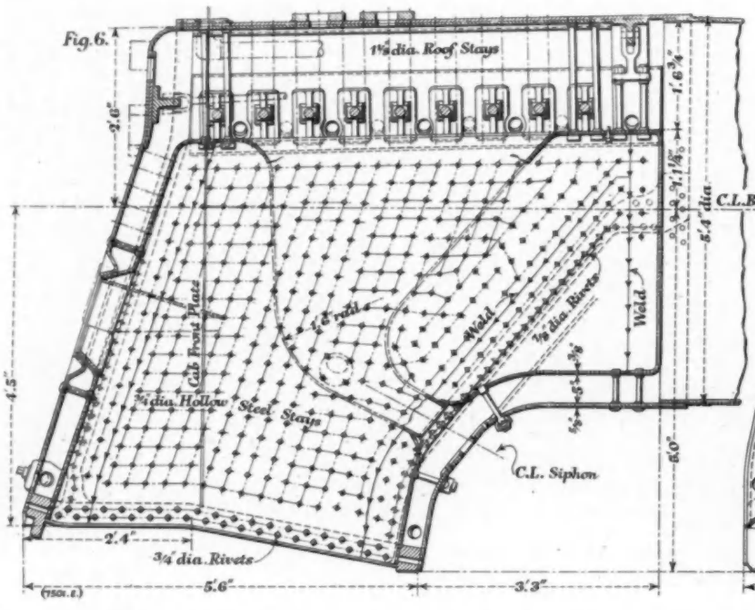
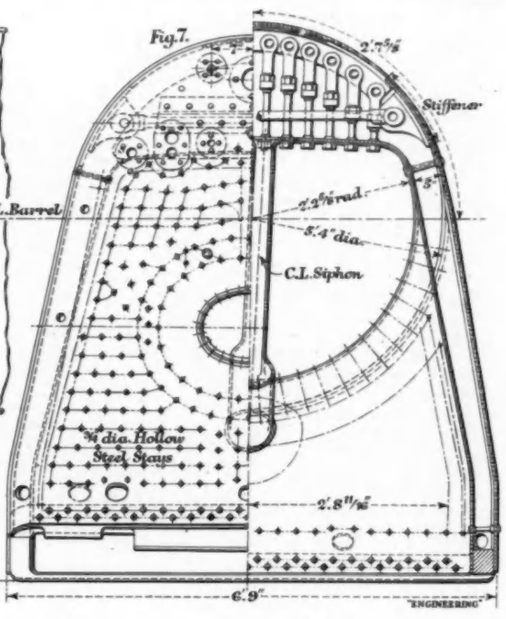


Fig.7.



(*Between pages* 266 *and* 267.)

UNIV. OF MICH.

MIXED-TRAFFIC LOCOMOTIVE; LONDON & NORTH EASTERN RLY.

SIR H. NIGEL GRESLEY, C.B.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 267).

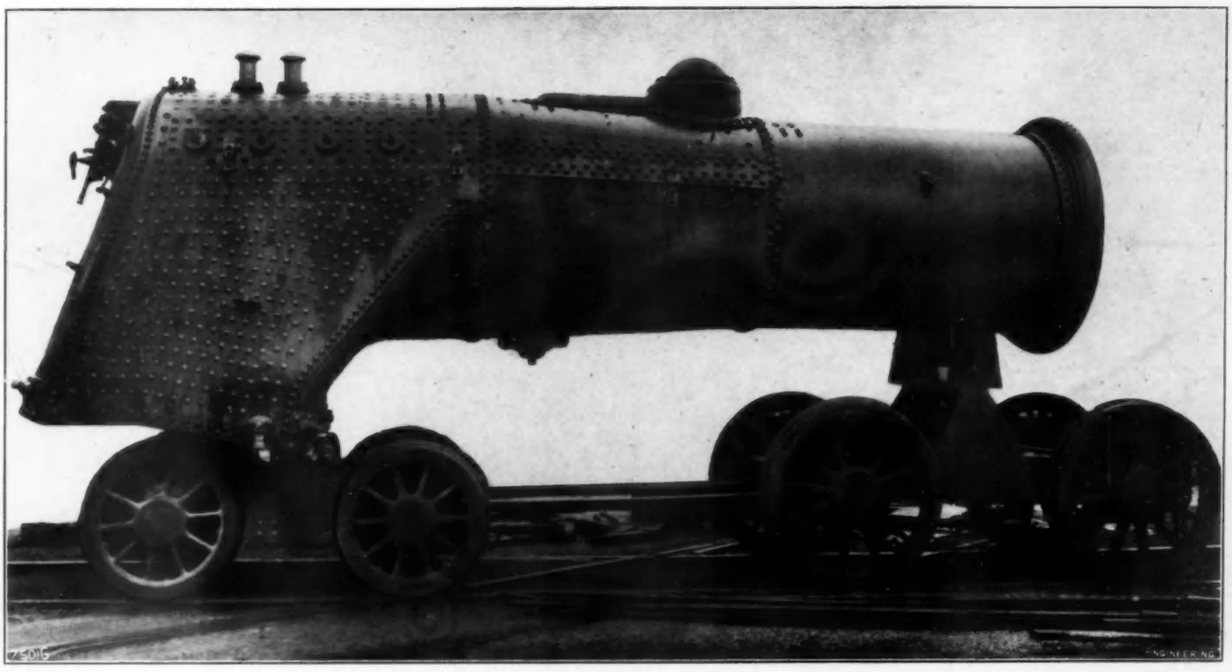


FIG. 8. GENERAL VIEW OF BOILER BEFORE ERECTION.

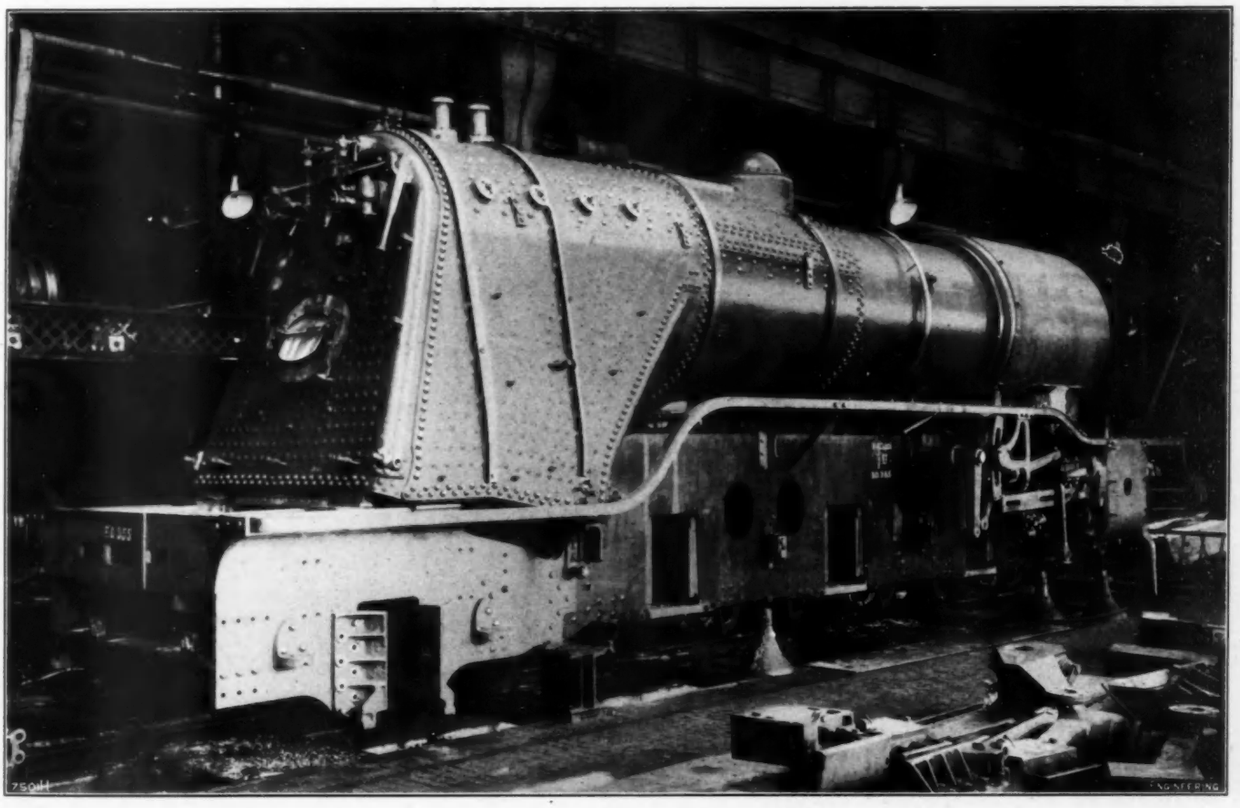


FIG. 9. BOILER MOUNTED ON FRAME.

(*Between pages* 266 *and* 267.)

UNIV. OF MICH.

2-6-2 MIXED-TRAFFIC LOCOMOTIVE; L.N.E.R.

SIR H. NIGEL GRESLEY, C.B.E., CHIEF MECHANICAL ENGINEER.

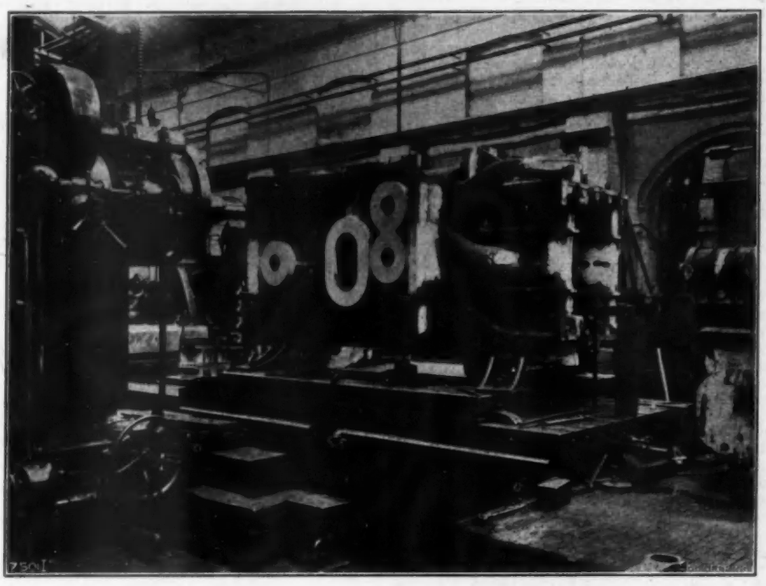


FIG. 10. MONOBLOC CYLINDER CASTING ON BORING MACHINE.

In this, the rubber is destructively distilled in a platinum boat in a current of nitrogen, the residue being weighed and then ignited in air to find the carbon by difference.

The present writer recently had occasion to determine copper by the colorimetric method described on page 30 of B.S. No. 903, using sodium diethyldithiocarbamate. The colour obtained has to be matched by adding, to a control, copper-sulphate solution containing 0·00001 gm. of copper per cubic centimetre. The method as given only allows determination of copper up to a maximum of 20 parts per million of rubber, which is below what most manufacturers would consider a safe limit for this element. The writer found it preferable to use a standard copper solution containing 0·0001 gm. of copper per cubic centimetre, and was interested to find, upon inquiry, that the Rubber Research Association did the same. The method as outlined seems to have been taken in its entirety from a paper by G. F. Palfrey, R. H. Hobert, A. F. Benning, and I. W. Dobratz.

It is a pity the analyst should be given little assistance in the practical interpretation of his results, which, after all, is the most difficult and important aspect of his work. On page 27 of B.S. No. 903 the following expression is given for calculating rubber content:—Rubber content = [100 − (acetone extract + chloroform extract + alcoholic-potash extract + "total fillers" + rubber-combined sulphur)] × 1·03. On page 7, however, it is stated that chloroform extracts from soft vulcanised rubber (previously subjected to extraction with acetone) about half of that fraction of mineral rubber (bitumen) which remains unextracted by acetone; therefore, in the above equation, the term "chloroform extract" should be multiplied by 2.

With the exception mentioned earlier, the methods recommended for the physical testing of soft vulcanised rubber and ebonite seem to be above question. It is expected, however, that the scope of the work will soon be extended to cover dynamic tests of resilience, as afforded by the Dunlop pendulum and the Goodrich flexometer; and heat generation under repeated stress, perhaps by the instrument last mentioned and the compressed rolling-ball test. A recognised means of assessing the state of cure is needed. Doubtless it will be found eventually in a low-temperature set test, such as the "T.50."

MIXED-TRAFFIC LOCOMOTIVE FOR THE L.N.E.R.

ALTHOUGH the exigencies of war have naturally retarded the normal development programmes of the British railways, they have not entirely arrested the plans for new locomotive construction, some of which were in an advanced stage of preparation when the outbreak of hostilities interrupted their fulfilment. The new 2-6-2 mixed-traffic locomotive, which is now being put into service by the London and North Eastern Railway, is a case in point. Designed shortly before the war by Sir Nigel Gresley, C.B.E., the company's chief mechanical engineer (to whom we are indebted for the details here given), for working over sections of the system where the 22 tons axle load of the earlier "Green Arrow" class cannot be permitted, the new type would have been put into service last summer if materials had been available a year ago for construction. That it has now been found possible to proceed with the programme may be taken, therefore, as an encouraging indication of the present state of British steel production.

It will be recalled that the "Green Arrow" (or "V.2 class," in the company's nomenclature) was introduced in 1936, when an illustrated description of the type appeared on page 704 of our 141st volume. The principal particulars may be recapitulated for comparison with those of the new "V.4" class. The "Green Arrow" has a boiler 6 ft. 5 in. in maximum diameter and 17 ft. between tubeplates, and a total evaporative heating surface of 2,431 sq. ft., to which the superheater adds another 680 sq. ft. The heating surface of the firebox amounts to 215 sq. ft. There are 43 superheater flue tubes, 5¼ in. in diameter, and 121 small tubes, 2¼ in. in diameter. The cross-sectional area through the flues is 519·4 sq. in. and through the small tubes 380 sq. in. The boiler pressure is 220 lb. per square inch, and the grate area is 41·25 sq. ft. The three cylinders have a bore of 18½ in. and a stroke of 26 in., and the driving wheels are 6 ft. 2 in. in diameter. The tractive effort, at 85 per cent. of the boiler pressure, is 33,730 lb. and the adhesive weight, 146,944 lb., giving an adhesive factor of 4·3. The six-wheeled tender carries 4,200 gallons of water and 7½ tons of coal. The weight of the engine, in running order, is 93 tons 2 cwt., and of the tender, 52 tons, making a total of 145 tons 2 cwt.; and the overall length of engine and tender is 66 ft. 5½ in. As previously mentioned, the axle loading is 22 tons, a circumstance which restricts the use of the V.2 class to only 2,752 miles out of the 6,414 route miles comprised in the system of the London and North Eastern Railway.

As an initial instalment of the V.4 class, two engines have been built, and the first of these, the "Bantam Cock," is illustrated in Figs. 1, 2, 4 and 5, and Figs. 8 to 12, on this and the opposite pages, on Plates XX and XXI, and on page 270. This engine has a copper firebox and copper stays, but the second engine, which is to be put into traffic shortly, has a steel firebox, fitted with a single Nicholson thermic siphon, views of which are given in Figs. 3, 6 and 7, on Plate XX. It will be seen that, in contradistinction to most of the new engines of modern type built during the past 20 years for service on the London and North Eastern system, which have been of large size and power, the V.4 class is of medium power; but in its design there have been incorporated the features of high boiler pressure and high superheat, three cylinders, long valve travel and the use of Sir Nigel Gresley's type of valve gear, which have been so successfully employed in the larger engines. In the past, the design of engines of medium weight and power which were intended to be run on lines other than the main routes has been frequently influenced by the length of existing turntables; but, for some years, the London and North Eastern Railway has been gradually replacing the older small turntables by larger ones of modern type, and thus it has been possible to introduce longer engines, embodying the above features, with economical results.

The principal dimensions and weights of the V.4 engine are shown in Fig. 2, opposite. The extreme width, over the footplate at the cab, is 8 ft. 9½ in. The particulars corresponding to those given above for the V.2 class are: boiler, 5 ft. 4 in. in maximum diameter and 13 ft. 6 in. between tubeplates; total evaporative heating surface, 1,444·1 sq. ft., and superheater, 355·8 sq. ft., making a total of 1,799·9 sq. ft.; heating surface of copper firebox, 151·6 sq. ft.; superheater flue tubes, 22 in number, 5½ in. in diameter; small tubes, 143 in number, 1¾ in. in outside diameter and 11 w.g. thick; cross-sectional area through the flues, 265·73 sq. in., and through the small tubes, 255·6 sq. in.; boiler pressure, 250 lb. per square inch; and grate area, 28·7 sq. ft. The three cylinders are 15 in. bore and 26 in. stroke, and the driving wheels are 5 ft. 8 in. in diameter. The tractive effort at 85 per cent. boiler pressure is 27,420 lb., and the adhesive weight, 108,752 lb., which corresponds to an adhesive factor of 3·96.

The weight of the engine, in working order, is 70 tons 8 cwt., and the weight of the tender 42 tons 15 cwt., giving a combined weight of 113 tons 3 cwt., or 31 tons 19 cwt. less than the "Green Arrow." This difference is partly accounted for by the smaller size of the tender, which carries only 3,500 gallons of water and 6 tons of coal, as against the 4,200 gallons and 7½ tons of the earlier type, and partly by the considerable reduction in overall length of the engine, which measures 29 ft. 4 in., compared with the 33 ft. 8 in. of the "Green Arrow"; but, to enable the V.4 type to conform to the weight restrictions imposed on secondary lines by the permanent-way department, considerable reductions of weight have been effected also by such means as the use of 2-per cent. nickel steel for the boiler barrel, and the extensive employment of fabricated construction, instead of steel castings, for such parts as the drag-box, main-frame stays, and the boiler supports. A lighter form of construction was also adopted for the footplate and its supporting angles and brackets. Fig. 12, on page 270, which is a view of the frame, looking from the back end, shows some of the positions in which welding has been used.

The boiler is illustrated in section in Fig. 3, on Plate XX, and in Figs. 8 and 9, on Plate XXI; and the copper firebox, in Figs. 4 and 5, on Plate XX. Fig. 3, as mentioned, actually shows the boiler of the second engine, fitted with the Nicholson siphon, but the dimensions of the barrel are the same in both cases; the parallel portion, 7 ft. 2⅛ in. long, is 4 ft. 8 in. in diameter, increasing to 5 ft. 4 in. at the firebox end of the tapered portion. The cylindrical shell plates are $\frac{17}{32}$ in. thick and the tapering shell plates, $\frac{9}{16}$ in. The front tubeplate is ⅝ in. thick. The tubeplate of the copper firebox is 1½ in. thick and the sides and crown, and the back plate, are $\frac{7}{16}$ in. thick. The crown stays are 1⅛ in. in diameter. The stays in the side and back water spaces vary in diameter from ⅞ in. to 1 in., according to position. A steam collector is provided immediately behind the dome, the steam passing to the slide-valve type regulator through a series of transverse ¾-in. slots in the barrel plate. The superheater header is of the Superheater Company's AX type, with ball joints to the elements, and separate saturated and superheated compartments. There are two 3-in. safety valves, of the Ross "pop" type.

The steel firebox, illustrated in Fig. 6 and 7, on Plate XX, has a tube plate $\frac{9}{16}$ in. thick, which is joined to the ½-in. plating of the inner shell by a Vee weld. The inner shell of the box, including the Nicholson siphon, is entirely welded. The joint with the outer shell at the fire hole is riveted. The stays are of the "Longstrand" hollow type, 1⅛ in. in diameter in the roof, and from ⅝ in. to ½ in. elsewhere. It is stated that this will be the first instance of a Nicholson siphon on a British railway, although it has been used extensively on the Continent and in America; and it is expected that valuable comparative data will be

provided by the performance of the two engines in service, on such questions as the relative efficiency, maintenance cost and general reliability of steel and copper fireboxes of the wide type.

In its intended purpose of promoting a more effective circulation of water over the firebox heating surface, the Nicholson siphon recalls some earlier efforts in the same direction, in which "mid-feathers" were employed. Sir Nigel Gresley's predecessor in office, Mr. Archibald Sturrock, designed a 0-6-0 engine in 1851, in which a transverse midfeather was provided across the centre of the firebox; 30 engines were built to this design, for the Great Northern Railway, by Messrs. E. B. Wilson and Company. In 1857, Mr. J. J. Cudworth designed some engines for the South Eastern Railway, in which a longitudinal midfeather extended to the back of the (copper) firebox, necessitating two fireholes. Similar midfeathers were used, in 1860, in 12 2-2-2 engines designed by Mr. Sturrock, and built by the firms of Messrs. Kitson and Company, Messrs. Sharp, Stewart and Company, and Messrs. Robert Stephenson and Company.

The use of the Nicholson siphon in the V.4 engine involves some difference in the area of firebox heating surface between the two engines so far constituting the class. The firebox area is increased by the presence of the siphon to 171·6 sq. ft. The height of the crown above the foundation ring is 5 ft. 9 in. at the front and 4 ft. 11⅛ in. at the back; the interior length at the top is 6 ft. 6⅛ in.; and the interior width, at the centre line of the boiler, is 4 ft. 4⅛ in. The length of the grate, measured along the slope, is 4 ft. 9⅞ in., and the width 5 ft. 11⅛ in. The outside overall length of the firebox is 9 ft. 1⅛ in., and the outside length and width at the bottom 5 ft. 6 in. and 6 ft. 9 in., respectively.

The three cylinders, together with the smokebox saddle, are a monobloc casting weighing nearly 4½ tons. Fig. 10, on page 267, shows this casting in process of machining. The piston heads and rods are integral forgings of Class C steel and drive the centre pair of coupled wheels through connecting rods, 7 ft. long, of nickel-chrome-molybdenum steel. The coupling rods are of Class C steel. The whole of the revolving masses, and 40 per cent. of the reciprocating masses, are balanced, the reciprocating balance of the inside engine being in the driving wheels and the revolving balance in the extended webs of the built-up crank axle. The balancing of the outside engine, both reciprocating and revolving, is equally distributed between the coupled wheels. Piston valves, 7 in. in diameter, are used, and have a maximum travel of 6⅛ in. The steam lap is 1⅛ in. for the outside cylinders and 1⅜ in. for the inside cylinder; there is no exhaust lap. The cut-off in full gear is at 70 per cent. of the stroke. The outside valves are actuated by Walschaerts gear, the suspension of the radius rod being arranged to accommodate the reversing shaft, as indicated in the outline diagram, Fig. 2, on account of the limited space between the leading coupled wheels and the driving wheels. The inside valve is operated by the Gresley gear, which has now been fitted to nearly 700 locomotives on the London and North Eastern Railway.

The leading pony truck is of the company's standard double swing-link type, allowing a translation of 4½ in. on either side of the centre line, and has wheels 3 ft. 2 in. in diameter, on an axle with journals 6½ in. in diameter and 9 in. long. The trailing wheels, of the same diameter, have Cartazzi axleboxes with journals 5½ in. in diameter and 10 in. long, and there is an inclination of 1 in 10 on the axlebox slides. These features, in conjunction with the short rigid wheelbase, enable the engine to negotiate curves of 4-chains radius. The journals of the coupled axles are 8½ in. in diameter and 9 in. long; those of the outside crank pins, 5 in. by 5½ in., and of the inside crank pins, 8½ in. by 6 in.; and those of the leading, driving and trailing coupled wheels, respectively, are 4½ in. by 3½ in., 6 in. by 4½ in., and 4 in. by 5 in. The springs of the pony truck are helical and of the Timmis section, with an outside diameter of 5½ in. and a free length of 10⅝ in. Elsewhere, laminated springs are used, those over the coupled wheels having nine plates 5 in. wide and ½ in. thick, attached at 3 ft. 6 in. centres. The trailing-truck springs are similar in section and number of plates, but are 4 ft. between centres. Braking is on the vacuum system, two cylinders, 21 in. in diameter operating blocks on the trailing side of each coupled wheel. The general design of the tender may be seen from the illustrations, but it may be mentioned that the tank is completely welded and that the drag boxes and frame stays are also fabricated.

THE BESSEMER GOLD MEDAL.—The Council of the Iron and Steel Institute has decided to award the Bessemer Gold Medal for 1941 to Dr. T. Swinden, of the Central Research Department, The United Steel Companies, Limited, in recognition of his original investigations in the metallurgy of steel and of his services in the organisation of research in the steel industry.

INSTITUTION ELECTIONS.

INSTITUTION OF ELECTRICAL ENGINEERS.

Associate Member to Member.—Harold Bentham, London, N.8; Percy Clegg, B.Sc. Tech., Macclesfield; Richard Leslie Hughes, B.Sc., London, N.10; Kenneth Hadley Tuson, Eastbourne; David Ronald Williams, B.Sc., Wolverhampton.

Associate Member.—John Williams Alexander, Swansea; Frederick Catherall, Manchester; William Dawson, Cardiff; Leslie Flather, Carlisle; Alan Weir Knight, Guildford; Kurt Konstantinowsky, Ph.D., London, N.13; Henry Lawson, London, N.14; Alexander Logan, Dunoon, Argyllshire; Thomas Lloyd Osborne, B.Sc., Manchester; Alexander Richardson, Southampton; David Scott Ryall, London, N.13; Flight Lieutenant Ian Alastair Scott, R.N.Z.A.F., Wellington, N.Z.; Rex Challingsworth Smith, Invercargill, N.Z.; Reginald William Tamkin, Brighton; David Gordon Tucker, B.Sc. (Eng.), London, N.W.10; Randolph Victor Vokes, Cardiff.

Associate to Associate Member.—John Harry Appleby, Letchworth, Herts; Frederick Byng, London, S.W.14; Flight Lieutenant William Arthur E. Featherstone, Saffron Walden, Essex; Leonard Cecil Gleaves, Beckenham, Kent; Thomas Daniel Griffiths, Swansea; Lieutenant Harold Victor Humphreys, R.E., Dartford, Kent; David Lewis, Tunbridge Wells.

Graduate to Associate Member.—Rupert Vernon S. Aleong, Trinidad, B.W.I.; Ian Lind Anderson, Durban, S. Africa; Ronald William Armstrong, Banstead, Surrey; Frederick William G. Bartlett, Bath; George Beal, Wallsend-on-Tyne; Gordon Biddle, Birmingham; Alexander Bothwell Blacklaws, Alexander Bay, Namaqualand, S. Africa; William Collinson, Worcester Park, Surrey; Seymour Cottrell, Dunfermline; James William Coysh, Manchester; Cyril Montague Dark, Castle-Douglas, Kirkcudbrightshire; Major Ahmad Adnan Hafiz, B.Sc. (Eng.), Baghdad, Iraq; Alexander Forsyth Hopkinson, Harrogate; Arthur Jack T. James, Walton-on-Thames; Edwin Faville Lodge, Johannesburg, S. Africa; James Dickie Morton, B.Sc., Ashington, Northumberland; Captain James Robert W. Murland, B.Sc. (Eng.), 5th Royal Inniskilling Dragoon Guards, Northampton; Arthur Stanley Oldhams, Pinner, Middx.; Charles James Phillips, Liverpool; Henry Thomas Priestley, Nambour, Queensland, Australia; William Robertson, Salisbury, S. Rhodesia; William Robinson, B.Sc. (Tech.), London, N.4; John Walter Snowdon, B.Sc. (Eng.), Haslemere, Surrey; Charles Ronald Taylor, B.Sc., Birmingham; William Aylmer L. Turner, B.A., Newcastle-upon-Tyne; Arthur Henry Uhl, Melbourne, Australia; Montague Vaughan, Esher, Surrey; John Albert P. Wakefield, Cape Town, S. Africa; Norman Watson, Newcastle-upon-Tyne; Evald Mattievich Whitaker, B.Sc., Rugby; William Lloyd Williams, Ferrybridge, Yorks; Raja Sulaiman Zainal, Ipoh, Perak, F.M.S.

Student to Associate Member.—Hugh Martyn Trainor, B.Sc. (Eng.), Cape Town, S. Africa.

INSTITUTION OF CIVIL ENGINEERS.

Member.—James Robert Beard, M.Sc. (*Manch.*), Esher, Surrey

Associate Member to Member.—Frederick Alfred Greaves, B.Sc. (Eng.) (*Lond.*), Leatherhead; Ernest George Horton, B.Sc. (Eng.) (*Lond.*), Northampton.

Associate Member.—Kenneth Derek Dawson, B.Sc. (*Manch.*), Plymouth; John Collins Dickson, B.A. (*Cantab*), Dunblane, Perthshire; Alexander Duff, Elderslie, Renfrewshire; George Albert Gepfert, Sutton, Surrey; Alexander Gray, Sunderland; Godfrey Kinnaird Haselden, B.Sc. (Eng.) (*Lond.*), London, N.W.11; Robert Moffat Hood, Newcastle-upon-Tyne; Bruce Lancelot Fortescue Hubbard, M.C., B.Sc. (Eng.) (*Lond.*), Sidcup, Kent; Trevor Vincent Martin, B.Sc. (Eng.) (*Lond.*), Brentwood, Essex; Wilfrid John Mills, Peterborough; Stephen Leonard Mitchell, Burnley; Alex Westley Skempton, M.Sc. (Eng.) (*Lond.*), Watford; Michael John Tomlinson, Scunthorpe, Lincs; Walter William Watson, London, S.E.26.

IRON AND STEEL CONTROL PROSECUTION.—At Willesden recently, a firm was fined for acquiring 18 tons 12 cwt. of steel without a licence. The case was brought under the Ministry of Supply Control of Iron and Steel Order, and it was stated for the prosecution that the defendants were largely engaged on Government work, that they were anxious to extend their factory premises, and that, for this work, it was necessary for them to acquire some steel. The symbol or reference number of an Air Ministry contract had been quoted, which, it was claimed, entitled the company to acquire the steel, but which, in fact, dealt with an entirely different matter. For the defence, it was stated that the firm had placed no direct orders for steel and that the extension was needed for storage purposes for vital work. The maintenance engineer stated that he had quoted the firm's authority number and had acted in good faith. A stay of execution was granted pending a possible appeal.

PERSONAL.

The Board of Trade informs us that the address of the IMPORT LICENSING DEPARTMENT, as from April 1, and that of the MACHINERY LICENCES DIVISION of the INDUSTRIAL SUPPLIES DEPARTMENT, as from April 3, is 1-6, Tavistock-square, London, W.C.1. (Telephone, EUSton 4433.)

MR. J. LESFORD is to continue in office as chairman of the North-Western centre of the Institution of Automobile Engineers for a further session.

MR. S. C. BRITTON, M.A., of the Metallurgical Department (Engineering Section), London Midland and Scottish Railway, Derby, has been awarded the Herbert Jackson Prize of the railway company, for 1940, for his paper, "The Corrosion of Copper and Some Copper Alloys in Atmospheres Highly Polluted with Coal Smoke." The paper is shortly to be presented to the Institute of Metals.

MR. G. S. MAGINNESS has succeeded MR. HAROLD BUTLER as President of the Machine Tool Trades Association. Mr. Butler relinquished the office recently after occupying it for three years.

MESSRS. EDWARD DEANE AND BEAL, LIMITED, condenser manufacturers, have removed to 34, Albion-road, Sutton, Surrey.

MR. S. H. WEST has been elected a director of Messrs. S. E. Opperman, Limited, engineers and gear cutters, 168, North Circular-road, London, N.W.10.

The Ministry of Shipping has appointed SIR WILLIAM REARDON-SMITH as regional representative for the Bristol Channel ports. MR. J. R. HORHOUSE is to act in a similar capacity for the ports from Holyhead to Silloth, and MR. J. C. DENHOLM for the Clyde Area. They will be concerned with all matters affecting the expeditious handling of deep-sea shipping within their areas and will work in close co-operation with the district and deputy representatives and with other authorities at the various ports.

MR. R. J. LOW, M.I.Chem.E., A.M.I.Mech.E., formerly chief engineer of Messrs. Howards and Sons, Limited, Ilford, joined Messrs. Fredk. Boehm, Limited, Seeleys Orchard, Penn-road, Beaconsfield, Bucks, on April 1, and is now acting in a similar capacity for them and their associated companies.

LORD REITH, Minister of Works and Buildings, and SIR WILFRID GREENE, Master of the Rolls and chairman of the newly-formed National Buildings Record, have been made Honorary Fellows of the Royal Institute of British Architects.

MR. E. V. EVANS, O.B.E., F.I.C., M.I.Chem.E., has been elected a vice-president of the Institution of Gas Engineers.

MR. JOHN SUTHERLAND, M.B.E., M.I.Chem.E., has been appointed a managing director of Messrs. B. Laporte, Limited, chemical manufacturers, Luton, Beds.

The services of MR. FRANK BERRY, M.Sc., have been loaned, by Messrs. Lever Brothers and Unilever, Limited, to one of the new Royal Ordnance Factories, for the duration of the war.

MR. C. MCCULLOCH has been appointed chief engineer to the joint works of Messrs. Hardman and Holden, Limited, and Messrs. Manchester Oxide Company, Limited, Miles Platting, Manchester.

MR. R. K. MACDOWALL has been seconded from the Institute for Research in Agricultural Engineering of the University of Oxford to the Salvage Department of the Ministry of Supply.

DR. E. KIHN, B.Sc., A.R.C.Sc., D.I.C., has joined the staff of the Engineering and Construction Division of the Koppers Company, Pittsburgh, U.S.A.

MR. E. C. TEAGUE has retired from the position of works manager of Messrs. British Timken, Limited, Cheston-road, Aston, Birmingham, a position he has held for many years. He is succeeded by MR. D. MCNICOLL, formerly export sales manager and latterly deputy works manager. MR. C. R. D. TUCKEY, recently appointed chief of the planning department, has now been made assistant works manager.

MR. A. WHISTON has been appointed works manager of Messrs. Fischer Bearings Company, Limited, Wolverhampton.

SIR CECIL WEIR, K.B.E., M.C., has been made Controller-General of Factory and Storage Premises. He will take up his duties shortly and a further announcement will then be made with regard to the central and regional organisation of the Control and the date from which it will operate.

WILBUR WRIGHT MEMORIAL LECTURE.—The 29th Wilbur Wright Memorial Lecture of the Royal Aeronautical Society will be delivered by Mr. J. T. Trippe, M.A., President, Pan American Airways Incorporated, at 6.30 p.m., on Thursday, May 15, in the lecture theatre of the Institution of Electrical Engineers, Victoria Embankment, London, W.C.2. The subject of the lecture will be "Ocean Air Transport."

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Delays in completing contract deliveries was again causing considerable comment on the Welsh steam-coal market. It was stated that consumers in the West Country had been unable to secure supplies of Welsh or Forest of Dean coals under contracts and had been told that they would have to take Durham coal. Local producers, it was pointed out, were working under considerable difficulties, but regular deliveries were being made to inland users. It will be remembered that a committee composed of representatives of the railway company and the coal owners was formed in January last to distribute the wagons allocated to the district equitably. Complaints were being made, however, that the allocation of wagons to the district was considerably below requirements. Producers again encountered a brisk demand from home industrial users for the high-volatile bituminous coals. Outputs of the dry-steam sorts were moving off satisfactorily, chiefly on Eireann account. Foreign trade continued to be confined chiefly to the South American and Portuguese markets. Best large qualities were in good demand, but the sized kinds were still scarce, and the occasional odd parcels available were quickly taken up. Bituminous smalls were difficult to secure, but dry steam smalls remained plentiful and dull. Cokes were busy and strong, but patent fuel was slow.

The Iron and Steel Trade.—The demand in the iron and steel and allied trades was briskly maintained, but owing to recent heavy sales new business was not easy to arrange. The works are still engaged almost to full capacity.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The demand for all classes of steel material is fully maintained. The bulk of the current production is required for Government contracts so that it is difficult to secure material for ordinary commercial purposes. There is no falling-off in the demand for ship plates. Light material is being consumed in large quantities. The makers of steel sheets are dealing with heavy demands for both black and galvanised varieties. The supply of raw materials is important, but good stocks are now in hand although these will require to be augmented. Prices are unchanged and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Conditions in the West of Scotland malleable-iron trade show no change and with a steady demand from consumers the works are fully employed. Bookings have recently been very good and regular employment is assured for some time. The re-rollers of steel bars are still fairly busy but owing to the high outputs during recent months they are able to meet their commitments and, in some cases, are now able to give early deliveries of new business. Stocks of raw material are ample for all requirements. To-day's prices are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The Scottish pig-iron makers are still fully employed and the heavy demands of consumers are being met with some difficulty. Both hematite and basic iron are in strong demand by steel-makers. Foundry iron is in fair request, with an improving tendency. The following are the market quotations: Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

LIGHT-DUTY PNEUMATIC DRILLS.—The great increase of female labour in many engineering shops necessitates, in some cases, modification of workshop appliances if fatigue from continuous use is to be avoided. One such instance is the drilling of the numerous small holes accompanying aircraft construction and to meet the demand for a light tool for work of this nature, Messrs. Broom and Wade, Limited, High Wycombe, have recently introduced a pneumatic drill, known as the "Supermite," which, with an overall length of 6½ in. and a weight of only 1¼ lb., is capable of drilling holes $\frac{1}{16}$ in. in diameter. The air consumption is 5·5 cub. ft. of free air per minute at a pressure of 80 lb. per square inch, and the air motor fitted ensures smooth vibrationless running with a practically silent exhaust. The throttle control is push-button operated by gripping the tool in the hand.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The present high level of iron and steel production, supplemented by substantial imports from the United States, is providing sufficient tonnage for all urgent requirements, but leaves little surplus available for ordinary industrial uses. A considerable proportion of the prospective output for the second quarter of the year has been already allocated and buyers with delivery licences have placed substantial orders.

Cleveland Iron Trade.—No movement towards an expansion of the meagre supply of Cleveland pig can be reported. The output is still light and intermittent and contributes little to the growing requirements of the North-East Coast foundries. Midland ironmasters, however, are still able to supply the requirements of foundry-iron consumers in this area and adequate deliveries of Midland brands are still coming to hand. Parcels of iron of particular qualities required for the production of certain particularly specified commodities are obtainable from Scotland and other producing centres. Merchants are managing to transact business on an increasing scale but the tonnage coming under their control is not sufficient to meet the demands of their regular customers. The stabilised values of Cleveland pig remain at the equivalent of No. 3 quality at 128*s.*, delivered in the Middlesbrough district.

Hematite.—Although hematite is still scarce, recent events encourage the hope that the situation may improve considerably in the near future. There is a possibility of an early increase in output and of a considerable expansion in the supply of American hematite. Meanwhile, customers are strictly rationed, delivery permits being granted only for supplies to consumers unable to make use of any other iron for the particular work on which they are engaged. The official quotations remain at the level of No. 1 grade of iron at 138*s.* 6*d.*, delivered to North of England buyers.

Basic Iron.—There is still no basic iron for sale but producers are maintaining outputs at a level that fully covers the heavy requirements of their own steelworks and occasionally provides a little excess tonnage for stock. The nominal market value of Tees-side basic iron is 120*s.* 6*d.*

Foreign Ore.—Imports of foreign ore are on a satisfactory scale. The much greater use of native ironstone, however, has reduced considerably the dependence on ore supplies from abroad.

Blast-Furnace Coke.—Buyers and sellers of Durham blast-furnace coke are not inclined to discuss new business. Local consumers are extensively covered and though sellers have large holdings they are not anxious to enter into further contracts until they have reduced their delivery commitments. Fixed prices are based on good medium qualities at 35*s.* 6*d.* f.o.r.

Manufactured Iron and Steel.—Semi-finished iron and steel is plentiful and is sufficient to maintain a maximum output at the re-rolling mills. All branches of the finished industry are busily employed. The substantial increase in the supply of steel, due largely to the arrival of larger tonnages of American products, is likely to speed up deliveries. The demand for bars, sheets, plates, and light sections is particularly pressing. Special alloy steels are in good request and specifications for railway material are being distributed freely. The principal market quotations include: Soft steel billets at 12*l.* 5*s.* per ton; hard billets at 13*l.* 12*s.* 6*d.* per ton; joists and sections at 15*l.* 8*s.* per ton; heavy plates at 16*l.* 3*s.* per ton; and heavy rails at 14*l.* 10*s.* 6*d.* per ton.

Scrap.—The supply of iron and steel scrap is still barely sufficient for the large and increasing requirements of the users, heavy steel scrap being in particularly strong demand.

THE CHEMICAL SOCIETY.—The Chemical Society attained its centenary on March 30. On account of the war, the arrangements for the celebration of the centenary have been postponed, but the hundredth annual general meeting was held at Burlington House on April 3, at which the election of the newly-elected President, Professor J. C. Philip, O.B.E., F.R.S., was announced, and the retiring President, Sir Robert Robinson, F.R.S., delivered his presidential address.

BETHLEHEM STEEL COMPANY'S NEW OPEN-HEARTH FURNACE.—A new 190-ton open-hearth furnace has recently been put into service at the Bethlehem Works, Pennsylvania, U.S.A., of the Bethlehem Steel Company. Excavation work for the foundations was commenced on November 18 and the furnace was completed and ready to receive its first charge on February 12, less than three months after the commencement of building operations. The heating medium is oil fuel but the furnace is also designed for the use of producer gas. The new furnace is the largest of its type at these works.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF CHEMICAL ENGINEERS.—To-day, 11 a.m., The Connaught Rooms, Great Queen-street, Kingsway, W.C.2. Nineteenth Annual Corporate Meeting. (i) Annual Report of the Council and Election of Officers and Council. (ii) Presidential Address: "Some Post-War Problems," by Mr. F. Heron Rogers. 12.45 p.m., luncheon.

JUNIOR INSTITUTION OF ENGINEERS.—To-night, 6 p.m., 39, Victoria-street, Westminster, S.W.1. Informal Meeting. "Some Historical Bronze Castings," by Mr. Robert Lowe.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Centre:* Saturday, April 5, 2.30 p.m., The Hotel Metropole, King-street, Leeds. "The Control of the Domestic Load," by Mr. P. Schiller, to be read by Mr. R. M. Longman.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*London Graduates' Branch:* Saturday, April 5, 3 p.m., 12, Hobart-place, S.W.1. "Aero-Engine Cooling," by Mr. C. D. Carmichael. *Institution:* Tuesday, April 8, 4.15 p.m., 12, Hobart-place, S.W.1. Annual General Meeting. Annual Report of the Council, Election of Council and Office-Bearers, and other formal business only.

INSTITUTION OF RUBBER INDUSTRY.—*London Section:* Monday, April 7, 5.30 p.m., Charing Cross Hotel, W.C.2. "Colloid Chemistry of Preserved Latex."—(i) "Distribution of Non-Rubber Substances," by Mr. H. C. Baker. (ii) "Applications of the Langmuir Trough," by Mr. W. G. Wren.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 8, 2.30 p.m., The E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. (i) "The Measurement or Ganging of Low Values of Illumination and Brightness," by Dr. J. W. T. Walsh. (ii) "Visibility by White and Coloured Light," by Mr. J. S. Dow.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 8, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual General Meeting. Papers on "The Selection and Training of Apprentices," by Messrs. J. B. Mavor, C. A. Packer and E. D. Russell.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Visits to representative steel and engineering works show that, while production is being maintained at a high level, research work is not being neglected, and important results have been obtained. A healthy tone prevails in the market for raw and semi-finished materials, and the steel-melting capacity is being taxed to the utmost at all the large works. Maintenance engineers are expecting a short break in operations at Easter, so that urgent repairs can be carried out. A substantial business continues to be done in both basic and acid materials, though railway requirements of the latter are not up to the standard of six months ago. Cold-drawn strip and wire rods are in steady request, and there is an ever-increasing call for precision-ground and cold-drawn bars. Intense activity continues to rule in the heavy machinery and engineering branches. Foundry shops, considerably extended during the past few years, are operating at full capacity, and castings of record size and weight are being produced. Good orders are on hand for hollow forgings and boiler drums. Makers of ironworks and steelworks machinery and related equipment are busily employed, and there is an increasing demand for electrical plant; for a considerable time this has been one of the most progressive sections of local industry.

South Yorkshire Coal Trade.—Large quantities of coal are being delivered at consuming works, where heavy stocks are being accumulated. There is an active market in industrial coal, and locomotive coal is in better demand; smalls and slacks are being delivered to power stations and gas works in larger tonnages. The house coal market is satisfactory, and all grades of coke are in strong demand.

EXPORT OF PAINT MATERIALS.—In response to representations made by the British Standards Institution on behalf of the paint and allied industries, the Ministry of Supply has agreed, as a war-time concession, to allow the conditions applicable to the carriage in passenger ships of paints having a flash point of 93 deg. F. to be extended to liquids having a flash point of 88 deg. F. This concession, it is stated, is a considerable help to the export trade and the increase in the available shipping space for paint materials will be most welcome.

MIXED-TRAFFIC LOCOMOTIVE FOR LONDON AND NORTH EASTERN RAILWAY.

SIR H. NIGEL GRESLEY, C.B.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see page* 267.)

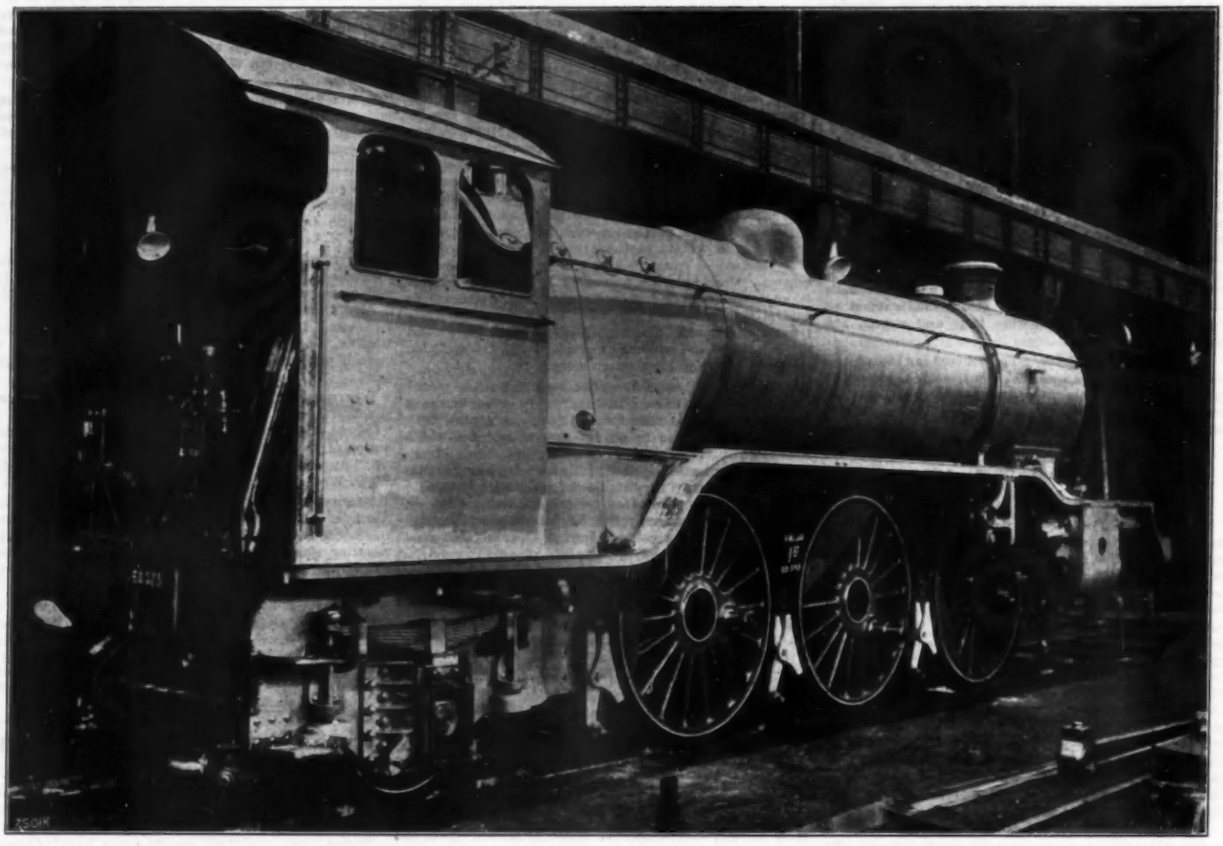


FIG. 11. LOCOMOTIVE IN ERECTING SHOP.

THE ROYAL METEOROLOGICAL SOCIETY.

A MEETING of the Royal Meteorological Society was held in their rooms at 49, Cromwell-road, South Kensington, London, S.W.7, on March 19, the President, Sir George Simpson, K.C.B., C.B.E., F.R.S., occupying the chair. A paper "On Cycles of Pressure, Especially in the Neighbourhood of Symmetry Points," was read by Professor L. W. Pollak, Ph.D. Dr. Pollak said that Schuster's criterion and the theory of probabilities had established extraordinarily few meteorological periods. The reason for the failure of periodogram analysis was that it was not applicable to damped oscillations. On the other hand, symmetry points in pressure variations appeared to indicate cycles of some persistency, and some short series had been analysed by Fuhrich's self-correlating method, of which a short summary was given in the paper. The importance of Brunt's criterion for utility had been shown by applying it to the periods of the motion of the earth's pole. Fuhrich's criterion for reality was then treated and several features were discussed, viz., independence of the analysis interval, the representation of artificial functions, and the case of equal amplitudes. Sixteen analyses of the pressure variations near symmetry points had been summarised, and it was found that a duration including two or three cycles, when analysed by Fuhrich's method, yielded a good representation of the variations with a correlation coefficient exceeding 0·8 between the observed and calculated data. The method appeared to be capable of giving at times a forecast of the pressure for 10 to 14 days in winter in central Europe.

The next paper taken was entitled "Variations in Annual, Seasonal and Monthly Rainfall over the British Isles, 1870 to 1939," and was by Dr. John Glasspoole. The paper included statistics of the general monthly rainfall over the British Isles, both in inches and as percentages of the average for the 70 years 1870-1939. The general trend of the variations was shown by diagrams of ten-year means for each month, based on the similar statistics for England and Wales, Scotland and Ireland, separately. Similar diagrams were given to show the variations, for the winter half-year, summer half-year and seasonal year separately.

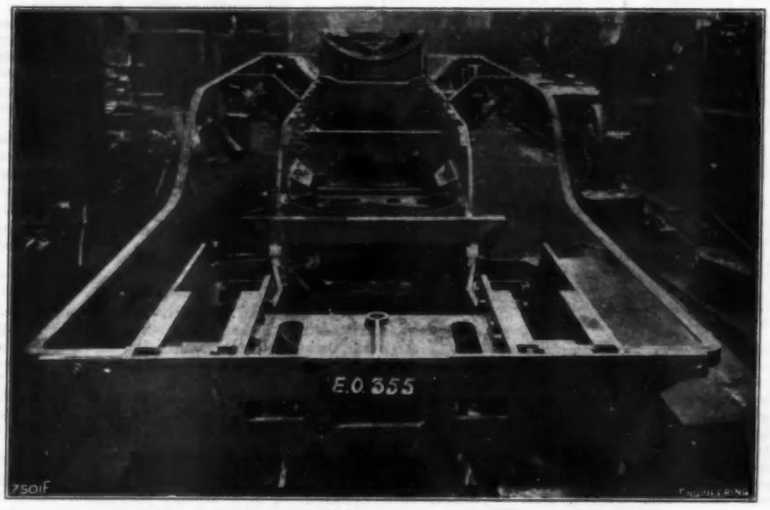


FIG. 12. UNDERFRAME, SHOWING WELDED CONSTRUCTION.

One other paper, entitled "Evaporation-Loss per Month over Drainage Areas, II: Loss Over Three Areas," was read by Mr. David Lloyd, M.Eng. In this paper, the data from three more large drainage areas were examined by the same method as in a former paper on this subject.

ENGINEERING.

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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Two One-Page Plates.—MIXED-TRAFFIC LOCOMOTIVE FOR THE LONDON AND NORTH EASTERN RAILWAY.

ENGINEERING

FRIDAY, APRIL 4, 1941.

VOL. 151. No. 3925.

INTERCRYSTALLINE CRACKING IN LOCOMOTIVE BOILERS.

ALTHOUGH the so-called "caustic embrittlement" of boiler plates by intercrystalline cracking has been the subject of systematic and widespread scientific investigation throughout the past 30 years, the problem remains incompletely solved as regards both causes and preventive measures. The triple character of its origins, involving mutual interactions among engineering, metallurgy and chemistry; the number and variety of the agencies that tend to promote intercrystalline cracking; and the practical difficulties of observation and experiment upon boilers in service, are all weighty reasons why progress has been slow and laborious. Indeed, the more that is known of these aspects, the more elusive appear the fundamental causes. At the same time, there is room for satisfaction that many of the conflicting views, not long ago hotly disputed, are gradually being reconciled in the light of wider knowledge, and that some means of prevention, as well as the principal contributory agencies, are established beyond all reasonable doubt. It may be accepted, for instance, that intercrystalline cracking occurs by the combined action of stress and of chemical attack, especially by concentrated solutions of sodium hydroxide; and nothing redounds more creditably to the pioneer work of Parr and Straub than their insistence upon this combination, despite the fact that the service failures within their experience included boilers having scantlings adequate to resist undue stress and containing water far too slightly alkaline to cause intercrystalline cracking directly. They found no fault with the design or workmanship of the boilers or with the material of the boiler plate, nor was anything unsatisfactory about the operation of the boilers in service, apart from the presence of sodium hydroxide in feed water of low sulphate content.

The explanations of these anomalous conditions, advanced in Straub's well-known paper,* have led to some recent developments of great practical interest. Guided by the observed fact that riveted joints were the most common sites for intercrystalline cracking, Straub arrived at the conclusion that high residual stresses were caused by stress concentrations around rivet holes, riveting forces, expansion of rivets, imperfect alignment of the holes in overlapping plates, and other factors producing deformation. The other essential could be explained by slight leakage at riveted seams, giving rise to a highly concentrated solution in contact with the stressed metal at crevices between plates and around rivets. Many of the objections against this assumption, raised on the grounds that cracking occurred in seams free from perceptible leakage, are probably invalid, since the necessary degree of leakage may be so slight as to be detectable only by refined means, and may take place only intermittently, associated with "breathing" or changes of boiler working conditions that make its detection a matter of the utmost practical difficulty. Not content with merely arguing along these lines, however, Straub demonstrated experimentally that high caustic concentration could occur in capillary passages joined to a body of dilute solution, in exact analogy with a perfectly steamtight seam, sealed by external caulking or rivet pressure but open internally to contact with the boiler water.

The work of Parr, Straub and their associates at the University of Illinois attracted world-wide attention, but gave rise to serious concern in the United States on account of the large number of areas in which embrittling boiler waters had been discovered. In particular, the American railroads regarded intercrystalline cracking as a principal or contributory factor in unexplained boiler failures of the past and as a potential source of future trouble, to be surmounted even at considerable cost. Accordingly, the investigation of boiler-plate embrittlement has been continued on an extensive scale by the experimental staff of the United States Bureau of Mines, with financial help from the Association of American Railroads and several other interested bodies. The consequent direction of attention towards the special problems of intercrystalline cracking in locomotive boilers has revealed several new points, and has indicated promising fresh lines of remedial approach of which some account was given in a paper* presented last year at the annual meeting of the Association of American Railroads.

Ample justification for the close concern of locomotive engineers is to be found in the assertions that approximately 500 locomotive boilers are known to have suffered embrittlement or intercrystalline cracking during service on American railroads, and that recent examples have been discovered on roads hitherto thought to be free from this trouble. It seems likely, indeed, that for some years to come locomotive boilers will be more susceptible than stationary ones, because they do not admit of such high precision in the control of feed-water conditioning, and because the straining and racking which they undergo on the track, as well as the absence of welded construction, render them more susceptible to the concentration of corrosive boiler water by leakage diffusion or evaporation in capillary crevices. Although, moreover, some diminution of intercrystalline cracking is to be expected from improved standards of workmanship and methods of manufacture, especially since the grave consequences of excessive local stress have been emphasised, the existence in service of many boilers that may be imperfect forbids any relaxation of feasible precautions. The difficulty of adequate supervision over locomotive stock is enhanced by the fact that the incipient stages of cracking are commonly hidden from inspection, the first intimation of distress being, if not a complete failure, at least a serious leakage, involving extensive repairs.

The possible existence of structural defects being thus unavoidable, Dr. Schroeder and his associates have approached the problem from the water side, to which purpose they have devised what they call an embrittlement detector. It consists, essentially, of a thick metal plate in which a hole can be connected at one end to the water of a boiler in normal service, while the other end is almost closed by a specimen of boiler plate under stress. Adjusting

* University of Illinois. Bulletin No. 216.

* "Intercrystalline Cracks in Locomotive Boilers" by Schroeder, Berk and O'Brien. Association of American Railroads (Mechanical Division), Circular No. D.V. 989.

screws regulate a minute diffusion of steam which produces a highly concentrated boiler water over the stressed surface of the specimen, all the conditions known to promote intercrystalline cracking being reproduced in an extreme degree. In particular, a continuous circulation past the leakage is achieved by connecting the apparatus to points at different levels on the end of the boiler. The results of laboratory and service tests, quoted by the inventors, show that the detector will rapidly and positively reveal intercrystalline cracking, and it is, therefore, of great value to the motive-power operator, who has to rely on feed-water treatment as his only available preventive measure. Its advantages over the routine water analyses and the corresponding control of water conditioning, necessitated by the use of perhaps hundreds of locomotives working over a wide geographical area, and receiving raw water from many different sources, are too obvious to need amplification.

On the other hand, the detector is open to criticism on the score that the specimen it tests must often differ from the uncertainly-known material of the boiler to which it is fitted, and may be in a different condition, as regards stress, heat treatment and surface finish, from those parts of the boiler most susceptible to intercrystalline cracking. By severely stressing the specimen, and periodically adjusting the leakage so as to maintain conditions of water concentration most conducive to cracking, the specimen will, no doubt, be vigorously attacked, to the degree that cracks can be discovered by microscopic examination in less time than is needed for the boiler to suffer serious damage. In this connection, the verisimilitude of the detector could be criticised because the regular adjustment of the leakage through the apparatus breaks the oxide film deposited on the surface of the specimen and thus imposes more severe conditions than those existing in the riveted seam of a boiler. The authors, anticipating this point, have made tests without adjusting the relative positions of the specimen and its baseplate, and obtained cracks in 22 days. In any case, it seems likely that the locomotive operator is primarily concerned to know whether the composition of the feed water is such as might lead to cracking, even if only under favourable conditions of stress and strain, and he would be unwise to depend on the boiler impurities being such as to produce an inhibiting film.

Among the attractive possibilities opened up by the use of the detector on locomotives in service is that of testing in advance the behaviour of alloy steels in respect of intercrystalline cracking. Research on the low-alloy "weight-saving" steels has already been started in America, possibly encouraged by the results of Schroeder and his colleagues with Izett* steel; which showed no better resistance than ordinary American boiler plate when Straub tested it over 10 years ago, but which (possibly improved since then) Schroeder now asserts to be definitely superior to any American boiler plate that has been tested in the embrittlement detector. The task of developing a thoroughly deoxidised aluminium-treated steel to surpass the Krupp product is already in hand by American metallurgists, though it remains to be demonstrated whether success in respect of resistance to embrittlement can be combined with all the other characteristics needed in locomotive boiler material.

For the time being, greater interest centres round the prevention of intercrystalline cracking by appropriate feed-water treatment, in which connection Schroeder and his co-workers have advanced in a number of promising directions. In the first place, their experience with locomotive boilers prevents them from sharing the high opinion of sodium sulphate held by Straub, as a deterrent to sodium-hydroxide embrittlement, and runs counter in this respect to the recommendations of the A.S.M.E. Boiler Construction Code. They have produced intercrystalline cracking, both in hot-rolled and cold-rolled steel, when the sodium-sulphate content of the water exceeded four times the sodium hydroxide. On the other hand, they have obtained good results with waste sulphite liquor—a by-product from certain processes of paper making, containing lignin in sufficient proportions to make it cheap enough for water treatment; though they are careful to remark that this organic reagent will not always inhibit cracking, notably under conditions of high residual stress in cold-rolled plate. Although, moreover, the good qualities of waste sulphite liquor are enhanced by the addition of such compounds as sodium aluminate, its protective action is reduced or nullified by high concentrations of sodium sulphate and sodium chloride.

The locomotive builder's attitude to this essentially chemical investigation tends—and not altogether without reason—to be that of the anxious layman waiting for the doctor to think out the proper prescription. It is important to bear in mind, however, that, on the basis of what appear to be well-established facts, the engineer himself can do a great deal towards minimising the risk of intercrystalline attack. In new boiler construction he can ensure that, by care in the choice of materials, in design, in shop practice, during erection and on trials, every effort is made to prevent damaging stresses in the metal. He can satisfy himself that his raw feed water does not contain more than 50 parts per million of sodium hydroxide, and that his water treatment is something better than the indiscriminate dumping of inorganic salts, without proof of their effects on embrittlement as well as on scale formation. Perhaps best of all, he can now use the embrittlement detector to investigate for himself the potential dangers of the feed waters in use throughout his railway system, while concurrently keeping a sharp look-out for symptoms disclosed by routine boiler inspection. Intercrystalline cracking appears to have given little trouble in British locomotives hitherto, but that does not mean that it cannot occur. Indeed, the recent introduction of large-scale water treatment on railways may be a predisposing cause of the trouble, and, though this possibility is fully recognised, it is plain common sense to anticipate and prevent it by every means that developments here and abroad may suggest.

* *Kruppsche Monatshefte*, vol. 7, No. 1926.

"MARE NOSTRUM."

The proprietary interest which Mussolini affects in the Mediterranean, and the desire to impress Mr. Matsuoka with some justification for it, was probably the main motive which took the Italian fleet out to sea last week on the voyage that has cost it so dearly. How dearly, may not be fully known for some time to come. Even if it turns out, however, that the Vittorio Veneto did succeed in getting back to port; that the Italian ships did not fire upon each other in the confusion of the night; that the 6-in. gunned cruiser, supposedly the Giovanni delle Bande Nere, was not sunk; and that the destroyer losses were confined to the two ships already named in the British Admiralty's communique; still, Admiral Cunningham can reflect that he has fought an action which, in the unequivocal character of its victory has few parallels in naval history.

The first report that Italian ships were at sea came from a reconnoitring aircraft at midday on March 27, when cruisers were sighted to the south-east of Sicily. Admiral Cunningham at once put to sea from Alexandria with the battleships Warspite (flag), Valiant and Barham, the aircraft-carrier Formidable and some destroyers, and headed to the north-west. The cruisers Orion, Ajax, Perth and Gloucester, with their escorting destroyers, were sent to the south of Crete, to intercept any attempt to interfere with Greek traffic. In the early morning of March 28, aircraft sighted a Littorio-class battleship, six cruisers and seven destroyers south of Crete, steering south-east; a force which was increased soon afterwards by the addition of two more cruisers and other destroyers. The British cruisers, under Vice-Admiral Pridham-Wippell, made contact with this combined fleet, and proceeded to lure it in the direction of the main British fleet. Successive torpedo-bomber attacks were made on the enemy battleship by machines operating from the Formidable, and at least five hits were claimed before nightfall, in addition to hits with bombs on other Italian vessels.

At 10.26 p.m., the main British fleet encountered the Italian cruisers, one of which, subsequently found to be the Pola, was lying damaged and stopped. By this time, darkness had fallen, but searchlights picked up the target ships and fire was opened with the battleships' main armament at about 4,000 yards range. The ensuing action appears to have been almost completely one-sided, for, although the Italian destroyers attacked with torpedoes, the avoiding action taken by the British ships was successful. The cruisers Zara and Fiume, and the destroyers Vincenzo Gioberti and Maestrale, were sunk; and the Pola, which surrendered to H.M.S. Jervis, was sunk by torpedo after 22 officers, including the captain, and 236 ratings had been taken off.

These details of the success of the British fleet are definite, but there have been various rumours of other losses having been sustained by the Italian navy, which are unsubstantiated at the time of writing. There is no doubt that the damage to the enemy battleship was severe, as her speed was observed to fall from some 30 knots to a mere 15 knots, and for some time she lay stopped, emitting clouds of smoke. Subsequent attempts by scouting aircraft to trace her whereabouts failed to locate her, so that there is some ground for presuming that she sank during the night. Sir Andrew Cunningham, however, appears to regard her escape as possible. The reports that two more destroyers were lost are based on messages from Athens, stating that survivors from four Italian destroyers had been landed there by units of the Greek Navy, which were co-operating with Admiral Cunningham's fleet. It does not follow, of course, that the number of ships lost tallies with the number of different cap-ribbons to be found among the rescued men, but there appears to be good reason for supposing that other ships than the two named may have suffered damage that necessitated their eventual abandonment. The least definite reports are those concerning the lighter Italian cruiser, which, it is suggested, may be the Giovanni delle Bande Nere, sister ship to the Bartolomeo Colleoni, which was sunk by H.M.A.S. Sydney in July of last year. She was the fourth ship of the cruiser squadron which was so severely handled by the British battleships and is known to have been heavily engaged. The probability that the enemy battleship was in action during the night with some of her own cruisers, coupled with the Italian claim to have sunk a British cruiser, indicates that the full tale of their cruiser losses has not yet been told.

Nelson, perhaps, might have regarded such a victory as incomplete, on the ground that a considerable number of the enemy vessels succeeded in escaping; but they escaped in such fashion that the moral effect of their survival on the personnel of the Italian fleet—and, indeed, on the Italian nation and its leaders—could hardly be more profound if they, too, had failed to return to port. Sir Andrew Cunningham inclined to under-statement in saying that "the action was a notable success over the enemy." It was much more than that, for its effect upon the spirits and continued efforts of the Allies, not to mention the United States, Jugoslavia, and Turkey, cannot easily be estimated; it might well prove, in the light of events yet to come, to have been a decisive turning point in the war, although it would be unduly optimistic to claim such a status for the battle at the present moment. From the tactical point of view, too, it is particularly interesting as the first instance of the employment of aircraft to prevent an enemy from profiting by his superior speed. Indeed, the close and effective co-operation between the Navy, the Fleet Air Arm and the Royal Air Force in this action makes it almost as great a triumph for the air forces as for the ships engaged; and the apparent failure of the Italians to use their own aircraft as scouts must have contributed materially to their defeat.

Not the least satisfactory incident was the whole-hearted tribute paid by Admiral Cunningham to the work of the naval engineers. "The contribution of the engine-room departments in this success," he declared in an interview reported by the British United Press, "cannot be over-emphasised. Their work, not only in keeping their ships steaming at high speed for long periods, but in the work of maintenance under most difficult conditions, has been most praiseworthy."

NOTES.

ROYAL SOCIETY ELECTIONS.

AT a recent meeting of the Royal Society, twenty new Fellows were elected. Of these, two are engineers, four are physicists and the remainder are engaged on research in the fields of geology, chemistry, mathematics, medicine, entomology and horticulture. The two engineers elected are both connected with Messrs. Rolls-Royce, Limited. They are Mr. A. A. Griffith, research engineer to the firm and formerly on the staff of the Royal Aircraft Establishment, Farnborough, and Mr. A. J. Rowledge, who, prior to 1937, was assistant engineer and is now consultant engineer to the firm. Mr. Griffith is responsible for research which has resulted in making notable contributions to existing knowledge on the strength of materials and to the development of aircraft and aero engines. Mr. Rowledge, who, before joining the staff of Messrs. Rolls-Royce, was chief designer to Messrs. D. Napier and Sons, has been responsible for innovations in the design and development of internal-combustion engines for motor vehicles and aircraft. Among the physicists honoured are Mr. R. A. Watson Watt, scientific adviser on telecommunications, Ministry of Aircraft Production, and formerly Superintendent, Radio Department, National Physical Laboratory; and Dr. F. E. Simon, reader in thermodynamics in the University of Oxford. It may be recalled that Dr. Simon is to deliver the 31st annual May Lecture of the Institute of Metals at Oxford, on May 28, when he will speak on "The Significance of Low-Temperature Research." The other two physicists elected are Dr. H. J. Bhabha, reader in theoretical physics at the Indian Institute of Science, Bangalore, and Mr. P. I. Dee, lecturer in physics, Cambridge University. Four of the new Fellows reside in the Antipodes, namely, Professor W. N. Benson, Professor of Geology, University of Otago, Dunedin, New Zealand; Professor T. G. Room, Professor of Mathematics in the University of Sydney; Dr. J. C. Eccles, also of Sydney, who is distinguished for his physiological researches; and Sir David Rivett, deputy chairman and chief executive officer of the Australian Council for Scientific and Industrial Research. The latter is a former Rhodes Scholar (Australia) and Professor of Chemistry in the University of Melbourne. Another chemist elected is Professor H. W. Melville, Professor of Chemistry in the University of Aberdeen and formerly a Fellow of Trinity College, Cambridge.

BRITISH TRANSPORT PROBLEMS.

Transport services, mainly by rail, and with special reference to the maintenance of sufficient supplies of coal, form the subject of the eighth report presented during the 1940-41 session of the House of Commons by the Select Committee on National Expenditure. The coal and wagon shortage, co-operation between coal merchants and sundry questions of transport re-organisation are discussed in the report, which contains some severe comments on the failure of the Government Departments concerned in the erection of new factories to acquaint the Mines Department with the probable future needs of districts in which the factories were to be located. Such oversights as these, it is pointed out, add materially to the difficulties of the railways, already heavily stressed by war traffic, much of which has had to be distributed over routes and in directions not customarily employed. Delay in loading and unloading wagons has aggravated the problem, and in this respect, it is noted, Government Departments themselves are not blameless. The defection of France caused an immediate fall in the demand for coal, with consequent unemployment in some colliery districts; while, in others, the men available could not cope with the orders in hand to meet domestic requirements. The Committee urge that the Government should make use of their powers of compulsion to solve the labour question, transferring unemployed miners to districts where work awaits them; and that, while difficulties of coal distribution persist, great caution should be exercised in calling men from the mines and the railways, for service in the armed Forces. Their recommendations, summarised, are that (1) more drastic steps should be taken to secure the speedier release of wagons; (2) a more comprehensive scheme should be planned, at once, to create coal stocks for next winter; (3) the labour question in mining areas should be "tackled resolutely," as indicated above; (4) the practicability should be considered of withdrawing passenger trains on specified days to permit more freight trains to be moved; (5) railway men and miners should not be called to the Colours unless this is absolutely necessary; (6) a scheme should be presented to Parliament without delay, for relieving individual coal consumers from the extra costs of coal brought from distant collieries; (7) the number of different grades of coal should be reduced; (8) closer co-operation should be organised among coal merchants, to pool requirements regarding stocks, labour and local transport; and (9) that Government departments concerned with the possible expansion of local needs for coal should provide the Mines Department with quarterly estimates, in advance, of the probable requirements in areas where supplies are, or may become, short.

THE WAR DAMAGE ACT.

The War Damage Act, which received the Royal Assent last week, is in two parts: The first applies to real property and is to be administered by a War Damage Commission, which is now being constituted. The second part relates to movable property, for which three distinct schemes have been prepared covering businesses, farmers and householders, and other private owners respectively. Responsibility for administering the schemes under this part of the Act will rest with the Board of Trade, who are setting up an Insurance Department for the purpose. It is understood that the Board will not issue policies directly to the holders, but that the latter will obtain them from their present brokers or the insurance companies. With certain exceptions, insurance under the business and farm schemes will be compulsory. Under the private chattels scheme, householders who wish to insure beyond the limits of free cover, which is 200*l.* for a single person and 300*l.* for a married couple, with an extra 25*l.* for each child under sixteen, will be able to do so at the rate of 1*l.* per cent. up to 2,000*l.*, 1*l.* 10*s.* per cent. for the next 1,000*l.*, and 2*l.* per cent. for the next 7,000*l.* The free cover for non-householders is 50*l.* It is also understood that the schemes dealing with industrial machinery, agricultural equipment and stock will be ready before Easter, and that for household goods by May 1. The benefits from all schemes will be retrospective from the beginning of the war. In order to be covered, it will be necessary to insure within 30 days of the particular scheme coming into force. Payment for damage, in general, will be deferred until after the war and interest at 2½ per cent. will accrue from the date of damage. Earlier payments, up to 100*l.*, may, however, be made in the case of businesses and farmers, if the Board of Trade is satisfied that the replacement or repair is in the public interest, and in the case of householders, up to 25*l.*, if the Board of Trade is satisfied that otherwise there would be undue hardship. The business scheme covers not only the machinery and plant of factories, but the professional equipment of doctors, dentists, barristers, solicitors and, presumably, engineers.

THE PROGRESS OF ELECTRIC TRACTION.

The annual Faraday Lecture of the Institution of Electrical Engineers, which it has been the custom to deliver in various provincial centres and, on occasion, in London as well, was this year given only at Newcastle-upon-Tyne. The lecturer was Mr. C. E. Fairburn, chief electrical engineer of the London Midland and Scottish Railway, his subject being "Electric Traction." In his opening remarks, Mr. Fairburn mentioned that contrary, perhaps, to the general belief, the first experiments with electric traction were made only a little later than those with steam traction on railways. These early experimenters were, however, premature, as electrical phenomena were very incompletely understood, and it was not until Faraday enunciated the fundamental principles that development became possible. Even then, it was not until 1879 that a successful electric vehicle was introduced. This was shown at a trade exhibition and its success led immediately to the construction of a short public tramway on the Continent. The first electric traction systems installed in the United Kingdom were those at Brighton and Portrush, in 1883. Dealing with the essentials of present-day practice, the lecturer laid stress on the simplification which had been achieved. For instance, the door-opening and closing equipment, which had replaced the attendants on the early London Underground trains, was now finding its way on to the main-line companies' trains. What was not so obvious was the reduction in the weight of the electric rolling stock that had taken place and the economies which arose therefrom. Although, so far, motor-coach trains had been used almost exclusively in Great Britain, other countries employed locomotives of considerable size; and a more general application of electric traction would necessarily result in similar applications here. It might sometimes be felt that, compared with other countries, developments in this country had been slow. It must be realised, however, that much of the development abroad was the result of special circumstances; for example, an abundance of water power or geographical conditions resulting in heavy gradients and long tunnels. In Great Britain, as coal was good and cheap, electric traction had to compete with steam traction.

THE PHYSICAL PROPERTIES OF INSULATING MATERIALS.

A paper, which was prepared for presentation before a cancelled meeting of the Association of Supervising Electrical Engineers, by Mr. P. C. Walmsley, dealt with those physical properties of common-place substances which render them suitable for use as electrical insulators. In doing this, the author discussed the different ways in which materials are produced commercially, in order to indicate the relative importance of those characteristics which guide selection for different uses. For instance, the indifferent demand for artificial silk, he considered, was due to price factors, and its performance was inferior to that of the natural product. Progress had been most apparent in untreated insulating papers, makers having secured uniformity both in structure and thickness. Cotton and sulphite-treated wood pulp were mostly employed for wrapping and as spacers, which were subsequently impregnated. Manilla and jute were of limited application and were principally used as reinforcing agents. The utility of paper press boards, presspahn and similar materials, when correctly employed, was beyond question. Among oils and resin impregnants shellac had partly yielded its position to synthetic resins, but was still pre-eminent for certain high-voltage applications where low working temperatures enabled its outstanding electrical properties to be fully exploited. Chemical reaction yielded resins from phenol and formaldehyde, and these could be dissolved in methylated spirits for coating materials or for binding fillers. The considerable differences in behaviour that affected the choice for given services made specialist fabrication advisable. Modern practice was tending towards the greater use of inorganic materials in built-up form, combined with binders. Of the apparently unending variety of synthetic substances some, like artificial rubber, could be made superior to the natural material, and treated glass fibre could be utilised under exceptionally severe operating conditions. Insulation manufacturers were being constantly confronted with demands which indicated that inquirers were sadly lacking in their knowledge of essential facts. Much was to be gained by revealing details concerning service conditions, and the best interests of the community would be served when there was active co-operation between insulation engineers and users.

THE MOBILISATION OF LABOUR.

This, we have often been told, is an engineers' war. It is somewhat remarkable, therefore, that, though preparations were made, even before hostilities broke out, for compulsory enlistment into the fighting Forces, so little was done to take similar steps for the recruitment of suitable labour for munitions factories. Indeed, it is only quite recently that the Government have been tackling

this problem in the way it should have been approached long ago, and have been working out plans for relieving the shortage in one of the scarcest elements among means of production, namely, skilled labour. It may be laid down as axiomatic that all employers engaged on work of national importance should be able to exercise a lien on the skilled workers they require. The stern facts are, however, that there is a distinct shortage of just this class of labour and that good tool-room workers of all-round excellence cannot be turned out overnight by mass-production methods. On the other hand, the war cannot be won without these men. Skilled labour, therefore, like so many other things, must be rationed while new workers are being trained. The manufacturers, too, must accept the position by utilising their key men to the best advantage, by dispensing with the services of those not urgently required and, above all, by training new men to fill the gaps. This means the application of dilution, upgrading and "de-skilling"; none of them popular processes. It also means the cutting out of all unnecessary skilled operations and the utilisation of the time of skilled men only on operations for which their high degree of skill is essential. In other words, machine setters should not be employed on repetition processes; and this is a field in which dilution, it is felt, can yield the best results. In the tool-room, too, the principles of division and specialisation can be applied with excellent results. This necessitates a lay-out on lines similar to those of a production unit, and the replacement of men of all-round experience by those with more specialised and limited knowledge. All this will require some sacrifice on the part of both employers and employed; on the part of the former, because some proportion both of their time and capacity will have to be devoted to training, and on the part of the latter because it will mean the temporary abrogation both of customs and regulations.

War Production in Northern Ireland.

Earnest readers of our daily contemporaries will have gathered that war production is not only being developed in this country, but also in the Dominions and in the Empire of India. It now appears that Northern Ireland is being organised to contribute to this effect in a more indirect, though none the less useful, way by assisting the work of firms in Great Britain, which are affected by the "concentration of industry" policy. The general principle underlying the scheme, which was discussed by Sir Basil Brooke, Minister of Commerce in Northern Ireland, last week, is that nucleus factories will undertake temporarily the civil production for a number of other firms, so freeing for munitions work the men and women displaced, as well as the productive capacity of the concerns affected. According to a statement made by Sir Basil, "Workers are urgently required for the production of munitions. As it happens, however, Northern Ireland does not possess munition factories which can absorb workers displaced by the shortage of raw materials or by the operation of the Limitation of Supplies Orders. We are most anxious to make our full contribution to the national effort and the new policy, announced by the President of the Board of Trade, involving the temporary placing in cold storage of a number of productive units presents an opportunity for industrialists in Northern Ireland to come to the help of such concerns by agreeing to undertake, for the duration of the war, the production of essential goods on their behalf." Sir Basil Brooke appeals to firms in the industries affected by the new rationalisation scheme to examine carefully the question of how they can play their part in the national effort by entering into negotiations for the establishment of nucleus industries in Northern Ireland, where a considerable amount of textile and other industrial capacity and skilled labour are available.

The Locomotive "Lion."—This old locomotive, which is the property of the Liverpool Engineering Society and has been for many years on exhibition in Lime-street station, has been removed to a place of comparative safety for the duration of the war.

INSTITUTION OF MECHANICAL ENGINEERS.

A general meeting of the Institution of Mechanical Engineers was held on Friday, March 21, at Storey's-gate, St. James's Park, London, S.W.1, the chair being occupied by the President, Mr. W. A. Stanier.

Munitions Labour Supply.

After the transaction of the formal business, the President called upon Mr. W. E. Denholm to read his paper, entitled "Munitions Labour Supply Organisation," an abridgment of which appeared on page 255, *ante*.

Mr. Stanier opened the discussion, commenting that, while appreciative reference was often made to the work done by trainees in the shops, he thought that the efforts of the management, foremen and others who had to reorganise their work to take in trainees should receive more credit and possibly a little encouragement when inspectors visited the shops.

Captain E. Latham, referring to the employment of women, said the problem was not so simple as it appeared. Cases involving married women required particular attention. He thought employers would be better able to judge of what a woman was capable in a workshop if photographs of women employed on various operations could be made available. These would be more informative than an ordinary descriptive bulletin, though both together might be still more effective. He would like more explanation of the part of the paper dealing with the placing of trainees. The several areas, naturally, had different industrial conditions, and in some areas, with a great variety of industries, the placing of women trainees was occasionally difficult. A difficulty in the general situation which sometimes occurred was the overlapping of inspectors' visits, where several departments were concerned.

Mr. Denholm, replying, said employers might well be better informed as to the capacity of women workers; in the area with which he was concerned, they were working, in one shop at least, to the fourth decimal place for limit work. In this area, there were difficulties in the case of married women with children, but attempts were always made to place them in works near their homes. This was also done with men, to avoid waste of time in travelling. There was no trouble with young unmarried women; they went into training and into the workshops without the slightest difficulty, and were producing good work. The overlapping of the inspectorates was now being eliminated by arranging conjoint visits. In the area he had referred to, the Government training centres served, in addition to the prime function, as an advertising medium. Directors and representatives of firms visited them to see what was being done. The actual placing was left entirely to the Supply Committee. The Inspectorate only placed the trainees from the technical colleges, and not those from the Government training centres.

The question of auxiliary training by employers was raised by Mr. W. T. Freestone, who enquired whether some remuneration was available for this service. He also asked if it was the fact that an employer was no longer free to start labour at his own door, and whether, although a man could not leave his employer directly, he could do so by depositing his card with the Labour Exchange. He maintained that many employers had made great progress in the training of labour, a point he thought little understood or appreciated by the numerous officials concerned. If it were an employer's intention to train his labour, he hardly required instruction in how to do it; and, further, when he had trained people, it was unfair to take them away from him. Employers approached the Labour Exchange to find out to what extent they could receive support. In some districts, no support was forthcoming. In his own district, employers were prepared to upgrade a considerable number of men if they could get female labour to replace them, but, at the same time, some of the work was of a heavy character, so that women could not be employed on it. Difficulty sometimes arose from questions of priority, and he submitted that the Labour Exchange should not be allowed to decide on this point.

In reply to the first of these queries, Mr. Denholm said he would read the statement issued by the Ministry of Labour on the subject, which ran: "The Ministry are prepared to give financial assistance to employers in respect of their workers who are engaged in instruction. When the employer allocates skilled workers whole-time on instruction duties, the Ministry will pay sums sufficient to enable him to pay upstanding salaries on the scale applicable to the instructors at the Government training centres. Where instructors are not whole-time on instruction, the Ministry are prepared to pay to the employer sums sufficient to enable the instructors to be recompensed for any loss of earnings owing to the time which they give to instruction. The intention is that the instructors should not suffer any loss of earnings of their part-time employment. In general, the payment for such part-time instruction will be calculated on the basis of the average earnings over the last four weeks of each instructor. If, however, in any case this amounts to less than the instructors would receive if they were paid at the rate of instructors at the Government training centres, they should be paid at the latter rate proportionately for any period during which they are actually engaged on instruction duties and the Ministry are prepared to pay the employer accordingly."

The only payment the employer obtained, Mr. Denholm continued, was when he deputed a man to act as instructor and he received a certain sum with which to pay that instructor. He had to provide the machine tools, the equipment and the training. In his own area, employers had recently been asked to make the foreman in charge of the shop the instructor, a plan which had overcome many difficulties. As regards men leaving their work by asking for their books, the employer could not legally refuse them, but he could pass the books on to the Labour Exchange and notify it that he wanted the man back, when the man would then be directed to return to the factory. No compulsion could be exercised; if it were, a man to whom it might be applied would be a drawback rather than an asset to an employer. Sometimes a disagreement would occur between a man and his foreman, and the former would go, but the employer might not be aware of this trouble and would apply to the Labour Exchange. As to the cases affected by priority, he thought the Labour Exchange manager was the only person who would be likely to know whether a man was employed in an industry of greater importance than that which he might be trying to leave. The rights of employers in the engagement of labour had not yet been restricted, but they might eventually be.

Mr. J. Mercer supported previous speakers in that he thought most firms had too many visits from inspectors. There was sometimes a difficulty in the question of rates of pay. It might be that a man who had been earning a bonus went to a works at which no bonuses, or smaller bonuses, were paid. If the employer gave him what he had been previously earning there might be trouble with the other men.

Miss V. W. Holmes said that, while it was generally acknowledged that women were good at repetition work, it was not realised that they might be equally good at work of a quite different character. In a certain area, a firm that had formerly employed men only on non-repetition work had now systematically trained a number of women. These were given a six-weeks' course and spent two and a half hours daily in a class room, chiefly on measuring instruments. At the end of the course the women went into the shops among the men and were allocated to different machines, doing their work in exactly the same way as a male trainee would do it. On centre lathes, the women were shown by the chargehand how to tackle the first piece and, after that, they carried on by themselves with great success. In a certain factory, where three-quarters of the output was precision work, of a total of 500 employees, 150 were women, who were carrying out grinding work to the fourth decimal place very satisfactorily, and were also doing inspection work

and a good deal of centre lathe work. The firm took some trainees and trained some women themselves, and were quite satisfied with the work the women were doing. From what she had heard of the Government training centres, she gathered that the authorities concerned were satisfied that the women trainees were doing as well as the men. As regards training women for supervisory duties, the Women's Engineering Society had started suitable courses long before the war. Three-quarters of the time was spent on practical workshop training. Most of the women subsequently went into works as operatives and did some work in this capacity before they attempted to supervise anyone else. Many of them entered firms that were only just beginning to employ women or were intending to employ women on the opening of new works.

The President here remarked that he was glad that Miss Holmes had emphasised the importance of supervisors taking three-quarters of their training in the shops. Unless a person had had practical training, he or she could not hope to exercise satisfactory supervision over other people.

Two questions asked by Mr. J. H. Child were, first, whether a request made to a Labour Exchange for the return of a juvenile would be attended to and, secondly, whether the question of possible abuse of medical certificates in connection with transfers had received any attention. Mr. Denholm replied that he was unable to give any information about juvenile transfers. The question of medical certificates was one calling for attention and, in some instances at all events, was now being looked into. The difficulty arose from the ignorance, perhaps excusable, of medical men as to the demands made by particular machines or work on an operative, and this sometimes enabled a man to present his case incorrectly. On the question of juvenile transfer, Mr. B. R. Hunter pointed out that directions for a juvenile to return to a place he had left could not be issued without reference to parents or guardians and the position was, therefore, more complicated than with adults.

Mr. Rex Wailes observed that most of the training schemes appeared to apply to fairly large shops. In his own works, with about 50 employees, it was not easy to arrange for training and up-grading, but, since he would not employ any unindentured apprentices, the normal training they got made them generally useful. Over a period of 17 years, only about three cases had proved unsatisfactory. Even these boys were not discharged on completion of their apprenticeship, but were retained until they could find work in other branches of engineering more suited to their capacity. With a small firm in a congested area it was not easy to employ women; for one thing, the provision of separate cloakroom accommodation presented a difficulty.

Mr. G. Nash said that, on the general question of workpeople being returned to their jobs, a request from a firm was not enough; the Labour Exchange must consider the circumstances of the individual, who might have a perfectly good case for exchange of work. The Labour Exchange, in instances where a valid reason did not exist, would do all that could be done to persuade a man to return, since an unwilling worker was of doubtful service. A man could be directed to return and was liable to a penalty if he did not obey, but the Labour Exchange was reluctant to take such measures, certainly in the case of juveniles. The new Essential Work Order, soon to be put into operation, would probably clarify the general position.

BRISTOL ENGINEERING DIRECTORY.—The Bristol Engineering Manufacturers' Association has recently issued the 1941 edition of the *Bristol Engineering Directory*. This contains a classified index to the engineering trades in the Bristol area, an alphabetical list of manufacturers and suppliers, and special articles on "The Functions of Factoring in the Engineering Trade," "The Heating and Ventilating of Buildings" and other subjects. Some technical tables of wire gauges in common use; V.I.R. cable sizes; the dimensions, etc., of bolts and nuts; the sizes, areas and weights of bright-drawn steel bars, etc., are included. Copies are obtainable on application to the honorary secretary of the Association, Mr. J. E. Evans, 104, Filton-avenue, Bristol, 7, enclosing 4*d*. in stamps for postage.

AN EARLY MARINE ENGINEERING INSTITUTION.

By ENG.-CAPT. EDGAR C. SMITH, O.B.E., R.N.

OF the members of the Institute of Marine Engineers who attended the annual general meeting and luncheon on March 14, to which we referred on page 233, *ante*, probably few were aware that the Institute, which was founded in 1889, had a forerunner in an almost forgotten Institution of Marine Engineers which came into existence in January, 1876, and was active for about three years. Such information as is available to-day, about this Institution is to be found mainly in the pages of the monthly journal, the *Marine Engineering News*, the first issue of which (price 4*d*.) appeared on January 1, 1876, and which, in June, 1879, became our contemporary, *The Marine Engineer*. The first issue of the *News* consisted of twelve pages of letterpress and four pages of advertisements, and the most cursory glance at these reveals that its promotors were also the promotors of the Institution and that they were all consultants with offices in the city of London. The most active promotor was Matthew Augustus Soul, who was both secretary of the Institution and editor of the *News*. First and foremost a patent agent, Soul was ready, however, to supply drawings of machinery or the machinery itself, to prepare scientific and other works for the Press, or to introduce new inventions on commission.

Scarcely less active in the various undertakings was Nicholas Proctor Burgh, well known in the 'seventies as the author of various works on steam and marine steam machinery. He had been in practice as a consultant since 1859 and had become a member of the Institution of Mechanical Engineers in 1870. He was elected the first president of the Institution of Marine Engineers, the first vice-president being E. B. Barnard, another consulting marine engineer. The first treasurer was J. S. Starnes, a maker of distillers, ventilators, hearths, etc., for ships, while the members of council included D. L. Selkirk, then London agent for W. Simons and Company, Renfrew and Bow, McLachlan and Company, Paisley, J. Smith, G. J. Cross, S. A. Johnson, J. Harding, G. Campbell, and W. H. Sissons, who had been "manager of engineers" with Ravenhill, Hodgson and Company, but who, in 1876, was prepared to coach engineers for Board of Trade examinations.

The first issue of the *News* opened with an "Address to our Readers," which referred to "the recent establishment of the Institution of Marine Engineers," the proceedings of which would be faithfully reported. On page 7 was the announcement of the election of officers and of the dates and hours of meetings. Papers by the president and others were in preparation. On page 11 another note acclaimed the objects of the Institution and made special reference to the Registry of Unemployed Sea-Going Engineers, established to assist shipowners in obtaining the services of men of experience. It was proposed to found a museum of marine engineering and a reference library. A donor of books worth 5*l*. was eligible for election as an honorary life member. An unusual feature was the proposal to grant gratuities to engineers sustaining losses through shipwreck. The objects of the Institution as declared were, indeed, admirable.

In the first and third issues of the *News* was an unsigned article on "Marine Engines," clearly written by Burgh; and the third issue contained his presidential address, delivered on March 2, 1876. In this appeared the first hint that the Institution had sprung from an earlier association. Burgh dealt at length with the need for the Institution, and gave a comparative review of the marine engineer with his brother professionals. Next he turned to engines, boilers, steam and heat, and with regard to steam and heat he made some rather strange statements. "My investigations," he declared, "have given me the conclusion that latent heat is not an origin but is a resultant, and therefore merely a conventional term, and not the parent of sensible heat. Now, then, you will ask, what is heat? I answer that electricity is the origin—in fact, the only perpetual motion known, and when once the oxygen can amalgamate with carbon, then the sensible heat occurs. We now come to a simple solution, namely, that as electricity is the origin of heat, there must be electricity in steam, and from that we have to consider the best method of preserving that electrical action, because it is motion." What Burgh's auditors thought of this is not recorded. He was a confirmed optimist, and, in his closing passages, announced that the Institution would start a Widow and Orphans Fund, which he was sure would be supported by manufacturing and shipping firms; while he was "equally certain" that "from this evening the nation at large will be more aware of the gratitude they owe to the British marine engineer."

During 1876 and 1877 the *News* and the Institution seem to have progressed steadily, and from the pages of the former can be gleaned many interesting items of engineering history. Several times it contained a list of consulting marine engineers in London. One of these lists includes the famous names of Bramwell, Scott Russell, John Bourne, and Asplan Beldam, the last of whom became, in 1889, the first president of the present Institute of Marine Engineers. Papers read to the Institution included one by J. St. John S. Johnson, on "Detaching Boats from their Tackle at Sea," another by Selkirk on "Dredging," and a third by J. Harding on "Hydraulics as Applied to the Thames Steam Ferry." In November, 1876, the *News* reproduced two letters from ENGINEERING, one by "A Chief Engineer" and the other by "Neptune." Both were written from Liverpool, and both suggested the formation of a society similar to the Institution at that port. The Liverpool Association of Marine Engineers was actually inaugurated at a meeting held in rooms in the Temple, Dale-street, on June 11, 1877, and began with nearly 400 members. The inaugural meeting is recorded in the *News* for July, 1877. In the December issue of that year it is stated that the establishment of the Institution of Marine Engineers had led to the formation of a kindred society at Shanghai.

The *News* for 1878 opened with a sketch of the work of John Bourne. The article was accompanied by an excellent portrait, the only one known to the present writer. Bourne was then 66. Trained for a surgeon, he turned to marine engineering at the age of 20, and had a remarkably varied and interesting career. He died soon after 1885; the actual date is not known to the writer. He was well known for his *Treatise*, *Catechism* and *Handbook* of the steam engine, and *Treatise on the Screw Propeller*. It was the intention of the *News* to give other portraits, and in the issue for May, 1878, there appeared a good one of John Elder; but no others were published. On January 24, 1878, Anthony J. Davison, of London and Sunderland, was elected to succeed Burgh as president of the Institution, and Soul was elected an honorary life member. The membership of the Institution was then said to be steadily increasing. On March 21, Davison read his paper on "Marchant's Steam Pumps." Further papers were promised on injectors and incrustation.

Save that, towards the end of 1877, a reduction had been made in the entrance fees, there was no indication that the Institution was not as flourishing as it would have appeared. The *News*, however, devoted more than a page of its issue of July, 1878, to reiterating the objects of the society, the particulars of membership, and so forth. It was then definitely revealed that there had previously existed a "Registry of Engineers" for sea-going engineers, that this had been transferred from the East End to the heart of the City, and had been renamed the "Associated Marine Engineers"; and this, in turn, became, in 1876, the Institution of Marine Engineers. Simultaneously with the appearance of this further statement of the aims of the Institution, the Council decided that meetings should be held fortnightly, and that the inspection of papers required from candidates to join the Registry should be delegated to the secretary and one other officer. An announcement to this effect was published in the August issue of the *News*, and this is the last which can be learned

about the Institution and its affairs. The *News* did not appear again until April, 1879, and, in June of that year, it was renamed *The Marine Engineer*. Its pages can be searched in vain for any reference to Burgh or Soul, or the Institution they had so ardently promoted. So far as is known, the Institution published no lists of members or statements of accounts, and its exit is shrouded in mystery. Though Penn's, Maudslay's, Humphrys and Tennant's, Yarrow's and Thornycroft's works were in full swing in the 'seventies, none of their leading engineers were attracted to the Institution, and it is not certain that it was successful in its work for seagoing engineers. From what has been said, however, it will be clear that it has some claim to be remembered for its pioneering work.

LETTERS TO THE EDITOR.

THE EFFICIENCIES OF THE CENTRIFUGAL PUMP.

To the Editor of Engineering.

Sir,—Mr. G. Ure Reid, in his letter published in your issue of March 14, throws doubt on the possibility of a more uniform treatment being adopted. In the list given in my article, practically every authority had points of difference; either different names for the same thing or different definitions for the same name. Surely some order might be culled from this apparent chaos? Although the internal efficiencies may not be important commercially, they should be clearly defined, on account of their technical importance. The ambiguity in the terms has several times caused confusion, to my knowledge. I would suggest that the matter should be considered at some future date by the British Standards Institution, and their recommendations incorporated as an appendix to B.S.S. 599.

The statement that the fluid does not flow in the impeller channels, but that the vanes are being driven through the absolute streams, is difficult to understand. Surely, if, at one instant, fluid is at the entrance to a channel and a little later is at the exit, it can be said to have flowed through the channel. All energy losses involved in flowing through must be caused by fluid friction. It is also manifestly impossible for frictional effects to cause an increase in head. In the argument relative to entry conditions, Mr. Reid states that the modern authors assume pre-rotation in the impeller eye. If this is so, the absolute streamlines will be affected, and the argument that follows will no longer hold.

Nevertheless, the problem of the best vane angle at inlet is extremely intriguing. It is frequently assumed that the angle that gives shockless entry is of necessity the best; but is this so? There are at least three possible factors which influence the angle. (*a*) If shock is allowed, the relative velocity will be reduced, and the loss due to the wetted areas of the blades may be reduced more than the increase due to shock. (*b*) The increase of speed as the fluid passes over a rounded edge such as an aerofoil is in the neighbourhood of 20 per cent. If the relative velocity is very high, the acceleration produced when rounding the inlet tips of the vanes will reduce the pressure there to the vapour pressure of the fluid, thus producing cavitation and its attendant losses. (*c*) A steeper inlet angle may lead to a more favourable blade shape and certainly to a shorter passage, and thus reduce overall losses despite shock at inlet. Unless the pump is of very low specific speed, pre-rotation at entry must be very small. Fischer and Thoma* made instantaneous photographs, using a suitable method for showing up the flow. Their results may be best expressed in their own words, which are:—"It will be seen in these photographs that the variations from radial entrance are confined within very narrow limits. Pre-rotation of the water is noticeable only at very small discharges. The chief cause of this is the reverse flow from the impeller, and to a less extent in the relative frictional effect at very small discharges." In the discussion on this paper, Professor Angus said that, some years before, he had carried out a number of tests with radial guide blades at entry, and was unable to find that there was any effect. This evidence is clear and must be accepted for the less viscous fluids, such as water. It appears, therefore, that, if it has been found expedient to use steeper blade angles at inlet than those calculated to provide shockless entry, it must be for some other reasons, such as those stated.

Yours faithfully,

J. Jennings.

Aston Technical College,
Birmingham, 6.
March 27, 1941.

* *Trans. A.S.M.E.* (Hydraulics Division), 54-8, page 141.

GRAPHICAL CALCULATION OF RIGHT-ANGLE HELICAL GEARING.

To the Editor of Engineering.

Sir,—I wish to thank Mr. Paul Grodzinski for his letter, published in your issue of March 21, on page 234. The analytical method of finding the exact helical angle for the minimum centre distance which he describes is very useful for those cases in which greater accuracy is desired than can be obtained by the graphical method.

May I call your attention to an error which occurred in the article, on page 183, *ante*? The sentence dealing with the question of end thrust suggests that the two mating gears are of opposite hand, whereas, of course, the two gears in a pair of right-angle gears are of the same hand. The sentence referred to should therefore read:—"The question whether the gears are left or right hand is a matter of direction of rotation and end thrust."

Yours faithfully,

Henry W. Hobbs.

Spring Cottage, Marley-lane,
Shottermill, Haslemere, Surrey.
March 25, 1941.

A PROBLEM IN TIDAL MECHANICS.

To the Editor of Engineering.

Sir,—For the letter of Dr. Doodson, of the Liverpool Observatory and Tidal Institute, in your issue of March 7, I am grateful. It emphasises the important point that such of those components of the forces concerned as are vertical to the earth's surface cannot raise tides. This is the first occasion on which I have seen that warning, which applies not only to Sir George Darwin's exposition, but also ("the vertical components are negligible as regards raising tides") to the equilibrium theory, which, says Dr. Doodson, "is remote from actuality," as some of us had suspected. He very kindly refers me to Sir G. Darwin's book; this I had already purchased, but enemy action destroyed it before I was able to read it. However, it seems that the ultimate tide-producing forces are mainly (and, to me, mysteriously) "horizontal or tangential," and not vertical.

It is unfortunate, says Dr. Doodson, that non-scientific "explanations" continue to be issued from time to time, as these confuse the issues for students. With this opinion I respectfully agree; but I venture to suggest that if an authority on the subject, having warned us off the vertical components above-mentioned, would go a little farther and give engineers a simple explanation of the production of the two permanent tidal humps by the ultimate horizontal or tangential components, it would be grasped with grateful avidity by numerous engineers and students and should automatically put an end to the dissemination of the unscientific 'explanations" which even now persist, so long after Sir G. Darwin's work. We have had to put up with these "explanations" despite the careful presentation of this subject by scientists, because, it appears, no accurate and concise simple explanation exists to take their place. For such an explanation my letter in Engineering of February 21 was, and is, in effect, an appeal. So far it has produced an important pronouncement on one point alone.

Yours faithfully,

W. J. T.

March 9, 1941.

[We have received from Dr. Doodson an article amplifying his letter, published in Engineering of March 7, and we hope to print this fuller explanation in an early issue.—Ed., E.]

THE FUTURE OF APPRENTICESHIP.

To the Editor of Engineering.

Sir,—Like your correspondent, Mr. G. F. Johnson, I am disappointed that no one has commented upon the article by Mr. C. J. Atkins on the above subject; particularly as, at the present time, much discussion is taking place concerning the educational arrangements after the war. In a previous article, published in Engineering of July 22, 1938, I pointed out how, by developing the trade school, the Central European countries had seen that a steady flow of skilled labour was available for industry. It would appear that the trade school, *i.e.*, a school where a boy enters an organised course in a selected craft extending over, say, three years, before completing his apprenticeship in the works, has a definite place in our educational system.

Yours faithfully,

A. C. Kelsall.

Croydon Polytechnic,
Scarbrook-road, Croydon.
March 24, 1941.

LOW-VOLTAGE LIGHTING TRANSFORMERS.

Messrs. A. Reyrolle and Company, Limited, Hebburn-on-Tyne.

(*For Description, see Opposite Page.*)

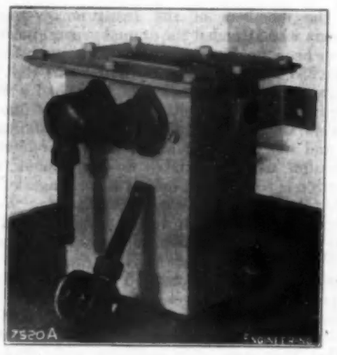

Fig. 1.

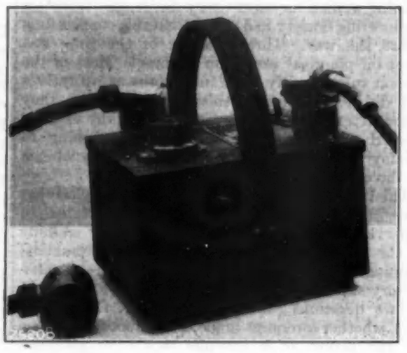

Fig. 2.

LOW-VOLTAGE TRANSFORMERS FOR LIGHTING CIRCUITS.

IT is generally recognised that one of the safest means of operating portable electrical apparatus is to supply them at as low a voltage as possible. To enable this to be done, Messrs. A. Reyrolle and Company, Limited, Hebburn-on-Tyne, have designed a transformer known as the Reylovolt. This gives 25 volts on the secondary side, while on the primary side it is provided with 200/210 volt, 220/230 volt, and 240/250 volt tappings, so that it can be connected to the ordinary supply mains. The standard wall mounting oil-cooled transformers, illustrated in Fig. 1, on the opposite page, are constructed in ratings of 50, 100, 250, 500 and 750 VA. In addition, a 50-VA air-cooled transformer is made for use in situations where portability is an advantage. An illustration of this is given in Fig. 2. In all the units an earthed metal shield is fitted between the primary and secondary windings, thus providing protection additional to that given by the insulation. The low-voltage winding is, therefore, unaffected by a breakdown on the supply side and the possibility of shock is eliminated. The middle point of the low-voltage winding is also connected to the terminal board, so that it is available for earthing, if required.

All the transformers comply with the appropriate British Standard specification. As already mentioned, the wall-mounting patterns are oil-cooled and are double-wound. The windings, which are insulated between layers, are wound on bobbins fitted round a laminated soft-iron core and the whole is totally enclosed in a rust-proof welded steel tank. As will be seen, this tank is provided with external fixing lugs for mounting on a wall or on a supporting framework. The supply cable can be led through conduit to either side of the tank, or alternatively may be taken right through with tee-off connections to the transformer. If only one side is used, a small screened plug is employed to blank-off the conduit entry. All connections are brought to a terminal board inside the tank. The low-voltage outlet in all sizes except the 750-VA (which is provided with conduit) consists of two special outlet plugs and sockets, which are mounted on the front of the tank. As shown in Fig. 1, these are provided with keys and slots, which are so arranged that a plug cannot be inserted into any but a corresponding low-voltage socket. In this way inadvertent connection of low-voltage apparatus to the mains supply is prevented.

The portable transformer, which is illustrated in Fig. 2, is air-cooled and is rated at 50 VA. As will be seen, it is enclosed in a ventilated teak case with a perforated sheet-metal lining, and is fitted with acid-resisting feet and leather carrying straps. In other respects it is similar to the wall-mounting pattern. The inlet plug complies with the British Standard specification and is suitable for tough rubber-sheathed flexible cable. A double-pole tumbler switch in the case permits of local control. Two special low-voltage outlet plugs are normally provided and are mounted on the top of the case. One of these may be omitted if desired.

Circumstances may arise in which it is appropriate to have a comparatively extensive low-voltage system, taking much greater energy than the largest Reylovolt transformer can supply; for example, a number of low-voltage points may be required in a large workshop. The necessary current can then be provided by one or more transformers of suitable ratio with their secondaries connected to a ring main. Low-voltage plugs and sockets of the kind fitted on the secondary side of the transformer can be used separately to form connecting points in the low-voltage system.

COMMODITY INSURANCE SCHEME.—The Board of Trade announces that considerable sums, in advance of the final settlement of claims under the commodity-insurance scheme of the War-Risks Insurance Act, have been paid to claimants within recent weeks. For the past two months the facilities for obtaining payment on account have been brought specially to the attention of every claimant who has given preliminary notice of claim. Printed directions, attached to each claim form issued, point out that where for any reason "there would be a genuine hardship if some financial assistance is not afforded to the insured person pending ascertainment and settlement of the ultimate proved loss," the Board of Trade is prepared to entertain an application for payment on account. Claimants are advised, in the directions, to write to the agent company, or Lloyds, through whom the policy was issued. It is pointed out that no special form is needed, but the policy-holder should state: (*a*) the address of the premises where the loss has occurred; (*b*) the date and cause of the loss; (*c*) the nature of the goods; (*d*) the estimated amount of the loss, allowing for salvage; and (*e*) the grounds of application for payment in advance of the final settlement.

LABOUR NOTES.

SPEAKING in London on Wednesday last week, Mr. Bevin, the Minister of Labour and National Service, said that there had been suggestions that some form of regulation ought to have been adopted to deal with the wage problem *en masse*. His own view was exactly the opposite. Procedure of the kind indicated would not permit of adjustments, in the industries themselves, called for by changes in operation, degrees of skill, the introduction of women, upgrading and a variety of other causes. All these matters had been dealt with by joint conciliation machinery within industries without ever really coming before the public. Yet in almost every instance there were the germ and possibilities of very serious disputes. Experience had demonstrated the wisdom of the policy that had been followed. The demand for the introduction of some untried and doubtful political procedure had come, in the main, he added, from those who had had little or no experience in the handling of industrial relations.

In the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in January are estimated to have resulted in an increase of about 470,300*l.* in the weekly full-time wages of about 3,250,000 workpeople. Of the estimated total increase of 470,300*l.* a week, about 3,150*l.* was due to the operation of sliding scales based on fluctuations in the proceeds of the coal mining industry; 69,500*l.* was due to arrangements made by joint standing bodies including 4,900*l.* under cost-of-living sliding scales arranged by such bodies; 143,000*l.* was due to the operation of other sliding scales based on the cost of living; 222,350*l.* was due to arbitration awards; and the remaining 32,300*l.* was the result of direct negotiations between employers and workpeople or their representatives.

According to the aeronautical correspondent of *The Times*, members of the Women's Auxiliary Air Force are now engaged in 25 trades formerly followed only by men. They are being trained as wireless telegraphy slip-readers and operators, instrument mechanics, fabric workers (aero), and fabric workers (balloon), sparking plug testers, equipment assistants, and cooks; for administrative duties and various clerical duties; as tele-printer operators, radio operators and tracers, telephone operators, four kinds of aircraft hands, dental clerk orderlies, and sick quarter attendants. Some of the R.A.F. doctors are women, but they do not form part of the W.A.A.F. Women who have been upholsterers, machinists, or tailoresses are found to be good at fabric work, while those who have had experience in factories or wireless shops usually make excellent instrument mechanics. Many former typists are employed as wireless telegraphy slip-reader operators, while among those whose task it is to trace in and colour maps are a number of women trained as commercial artists. The W.A.A.F. have their own directorate, their own training centres and officers. There is no direct entry for officers, all of whom are promoted from the ranks.

Under an agreement to which the Engineering and Allied Employers' National Federation and the engineering trade unions are parties, apprentices, youths and boys working in the industry will receive substantial wage increases this week. The principle adopted in the adjustment of the claims is to fix the minimum time rate of each lad at a certain percentage (according to age) of the base rate and bonus of the skilled fitter in his district. At the age of 16, the percentage is 25; at 17, 30; at 18, 42½; at 19, 50, and at 20, 60.

Boys and girls of 16 to 18, in training at Government centres, are to receive higher allowances as from March 31. A lad of 18, in training in his home area, will be allowed 23*s.* a week instead of 22*s.*, and girls of the same age will have their rate increased by 1*s.* to 21*s.* At the age of 17 the lad's rate will be 17*s.* instead of 15*s.*, and the girl's 15*s.* instead of 13*s.* 6*d.* Boys of 16 will be allowed 17*s.*—an increase of 5*s.*—and girls 15*s.* instead of 11*s.* A free mid-day meal (or 5*s.* a week) will be given to each trainee plus 24*s.* 6*d.* to a trainee working away from home who has to support a family. Normal dependents' allowances are to cease.

The British Employers' Confederation and the British Trades Union Congress gave a luncheon in London last week in honour of Mr. Winant, the United States Ambassador. The Prime Minister, who attended and addressed the gathering, said that we had brought into being a National Government—a Government which rested upon, as one of its main sources of strength, the trade-union organisation of the country. In the United States, during the presidency of Mr. Roosevelt, enormous efforts had been made to broaden the whole basis of industry and society, and on this side of the Atlantic that progress was being watched with the utmost interest and sympathy. But he knew that Mr. Winant would not think it critical and invidious, if he said that in this country we had been for several generations broadening and developing the trade-union movement. There had been differences from time to time, but everyone knew—and he had been taught it all his public life—that the employers of this country were deeply thankful that there was in existence a strong organised trade-union movement with which they could deal and which kept its bargains and moved along a strongly controlled and suitable path of policy.

"The trade union movement," Mr. Churchill went on to say, "has, willingly, agreed in this war to the temporary suspension of privileges which have taken generations to win. These have been handed over to the custody and keeping of the State, and without that we should not be able to produce under the severe conditions of the enemy's fire the immense output of munitions of all kinds which are needed if we are to let our soldiers, sailors and airmen meet the enemy on even terms of equipment. It is a matter of honour to the whole country that these privileges shall be restored and resumed when this crisis has passed away unless some better arrangements can be made."

An article in the *Journal* of the Railway Clerks' Association calls for a drastic re-organisation of transport. Important changes are imminent, it is suggested, in railway control. "Private interests which display undue selfishness may be confronted," the writer says, "with proposals which will startle them out of their complacency. It is imperative that all forms of internal transport be made complementary to each other. The idea that a war can be successfully conducted by allowing a large number of people, privately pursuing an element that is supremely vital, to do exactly what they like with it, or even to do nothing at all, is plainly absurd."

According to the political correspondent of the *Daily Herald*, the foregoing comment is in line with a rapidly growing demand for full public control of transport. "Here is a programme," he writes, "which has wide backing far beyond the ranks of the Labour and Trade Union Movement:—All main transport organisations should be taken over at once by the Government and run as a co-ordinated public service. A national transport authority should be set up to manage the service as a single operating unit. This authority should include representatives of the Government as owners, representatives of industry and the public as users, and representatives of transport staffs as workers. Railway transport should be linked with road transport—both goods and passenger—the ports, coastwise shipping and the canals in a comprehensive operating plan."

A conference at the Board of Trade last week between representatives of the Government, the colliery owners and the mine workers discussed various coal production problems. A large increase in the output of coal is required to meet the current needs of the munitions industries, and to ensure adequate reserves for next winter. An increase in output of 25,000,000 tons a year, or 12½ per cent., is wanted. Recognising the difficulties and the need to overcome them, the representatives of the colliery owners and the mine workers pledged themselves "to put forward every effort of the national, district and pit organisations to secure the fulfilment of the programme of production which has been submitted to the industry." The resolution added:—"It is essential for the Government to recognise the supreme national importance of the industry."

The labour troubles which are impeding production in the United States seem to be due not so much to unrest as to the long-drawn out conflict between the American Federation of Labour and the Congress of Industrial Organisations. Under American law, undertakings are empowered to bargain collectively with representative bodies elected by their employees. The A.F.L. is almost exclusively composed of craft unions, which naturally seek to represent their members in collective bargaining. The C.I.O., on the other hand, is composed of industrial unions, whose memberships are composed of workers of any degree of skill. The craft unions, of which the International Association of Machinists—the American body corresponding to our Amalgamated Engineering Union—is an important unit, resent, for obvious reasons, the aggressive action of the C.I.O. in seeking to represent their members on negotiating committees.

HOT-TINNING.*

By C. E. HOMER, B.Sc., Ph.D.

THE art of coating metals with tin by dipping them into the molten metal is of considerable antiquity, and it is still the most widely used method of tinning. Until recently, there was no satisfactory alternative tinning process, but in the last few years there have been considerable advances in the art of electro-depositing tin. Electro-tinning is now an entirely satisfactory process for industrial use, and gives effective protection to a variety of basis metals. It is not possible in a short space to discuss in detail which of the two methods is the more suitable for different types of work, since so many factors are involved, but it may be helpful to summarise the principal features of the hot-tinning process.

The process may readily be applied to mild steel, carbon steels, copper, and many copper alloys. It also gives satisfactory results on cast iron, provided that the basis metal is given special preparation. Some alloy steels and copper alloys are not suitable for hot-tinning. The average thickness of coatings applied to fabricated articles by hot-tinning is 0·0005 in. to 0·001 in. This is a limitation of the process, since for some purposes a much thicker coating would be an advantage, as it would give longer service. Electro-tinning, on the other hand, gives coatings of any desired thickness. Hot-tinning furnishes bright lustrous coatings without polishing, and they do not tarnish readily in the atmosphere. Electro-deposited tin coatings are mat when they emerge from the plating bath and give only a satin finish when polished. The plant required for hot-tinning is simple; for articles on which a finish of the best appearance is not essential, one tinning pot and an unheated pickling tank are all that is needed. Laboratory control of the process is not necessary. The tinning operation is rapid, since the time of dipping is generally only a few seconds. On the other hand, articles can usually be dipped only one at a time. Tin-lead alloy coatings may be applied as easily as pure tin, thus reducing the cost for certain types of work. The hot-dipping process can be used to effect tinning and soldering simultaneously, as in the manufacture of motor-car radiators. Fabricated parts containing soft-soldered joints cannot be hot-tinned without melting the solder in the joints. Brazed and welded joints are, however, unaffected by the heat of the tinning operation.

Usually, the hot-tinning process is operated by tinners who rely on their experience and personal skill rather than on scientific control. This is not surprising, since tinning is an old trade and one in which skilful manipulation is still necessary, even when facilities for scientific control are available. As a result, the process has been neglected by research workers, and has undergone little change over a considerable period of time. Literature and technical data on the subject are very scanty indeed, so that the technical staff of works engaged in tinning are rather hampered in their investigations of difficulties.

Articles to be tinned by hot-dipping are first carefully cleaned—usually by degreasing followed by acid pickling—and then dipped into the molten tin bath. To maintain the cleanliness of the surface of the article during dipping, a flux solution is previously applied to it. After immersion in the bath the article is withdrawn, and when the surplus tin has been drained off, it is allowed to cool. A departure from this basic procedure is made only when articles are too large to be immersed in the tin bath, or when it is desired to apply a coating to a portion of the surface only.

The production of a coating by this method involves an alloying of the tin with the basis metal, and the resulting coating consists of two layers. Next to the basis metal is a relatively thin layer of alloy, and above this is a layer of pure, or practically pure, tin. The alloy layer formed on iron or steel consists essentially of the intermetallic compound $FeSn_2$, while that on copper and its alloys consists of the compounds Cu_6Sn_5 and Cu_3Sn. Fig. 1, on this page, shows a micro-section of a tin coating on steel. The pure tin is uppermost, then follows the darker $FeSn_2$ under which is the steel. Fig. 2 is a micro-section of a tin coating on copper. The pure tin is uppermost; under this is the lighter Cu_6Sn_5, then follow the slightly darker Cu_3Sn and finally, the copper.

When tinning has been successfully carried out, a continuous layer of alloy covers the basis metal, and this is covered with a smooth, bright, uniform layer of pure tin. Inadequate preparation of the surface before tinning leads to a lack of continuity or uniformity in one or both layers. In bad cases there may be uncoated spots of an appreciable size where the tin has not adhered at all; more frequently, however, an apparently continuous compound layer is formed, but the pure tin will not form a uniform layer over it. Instead, it gathers into drops and streaks, behaving like water on a slightly greasy surface. This is one of the principal defects which may occur in hot-tinning and an instance of it is illustrated in Fig. 3, opposite. The phenomenon is known as "streakiness" but has recently been termed "de-wetting." The mechanism of de-wetting is still not fully understood, but most of the factors liable to cause it are known, and with proper technique it can be avoided.

A tinning bath consists of a steel or cast-iron pot mounted so that it may be heated conveniently by coal, gas, oil or electricity. Modern tinning baths are generally made as separate units, and most are gas-heated, though electric heating is being increasingly used for the smaller sizes. Thermostatic control is often employed. It is desirable to provide the baths with hoods and an efficient exhaust system, especially when using grease or sal-ammoniac in the tinning process, as these give off smoke or fumes, and if there is no exhaust system the atmosphere in the shop is seriously polluted. There is some difference of opinion as to the material of which the pots should be made. The usual practice is to construct them of welded mild-steel plate, but cast iron is preferred by some tinners as it is considered to prolong the life of the pot by reducing the rate of attack on it by the molten tin. No figures are available for the rate at which tin reacts with pots of different materials, but it may be said that under normal conditions the attack is very slow indeed. Even though the inside of the pot become

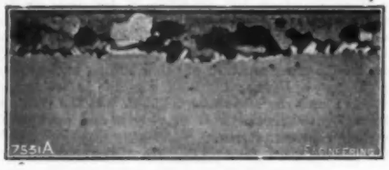

FIG. 1. TIN COATING ON STEEL. × 500.

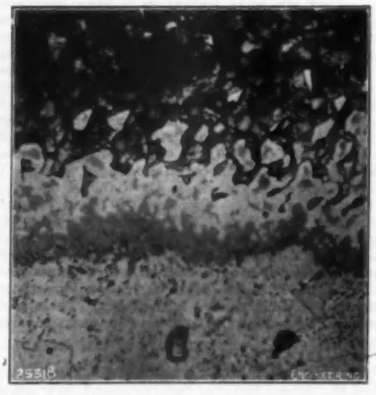

FIG. 2. TIN COATING ON COPPER. × 1,000.

tinned, there is generally little further action on it, whether made of steel or cast iron.

Tinning Steel and Iron.—Most of the steel tinned by hot-dipping is mild steel, although sometimes, for special purposes, it is necessary to tin medium-carbon and alloy steels. Mild steels and most plain carbon steels are intrinsically very suitable materials for tinning, while most alloy steels are rather difficult to tin satisfactorily. Most steel sheets and strip are coated with some oil or grease, applied to prevent rusting in storage, and when articles are fabricated from them more lubricant is applied. Usually, therefore, degreasing is necessary before pickling and tinning can be carried out successfully. Insufficient degreasing causes "de-wetting" of the coating when the steel is tinned. Three principal methods of degreasing are applied to steel intended for tinning, and these employ organic solvents, alkaline solutions, and heat, respectively. The organic solvent generally used is trichlorethylene, and cleaning is effected by placing the articles either in the hot liquor or in the vapour. The cleaning of greasy steels in alkaline solutions is rather difficult, since many of the oils and greases met with are not saponified, and are only slowly removed by the usual alkalis such as caustic soda and sodium carbonate. A good deal of research has been carried out recently on this subject, however, and manufacturers have developed alkaline cleaning agents which are both effective and rapid in action.

The method of heating or "burning-off" is commonly used, and may often be combined with the annealing required after deep-drawing or pressing. It is very effective provided that the correct temperature is reached. This depends upon the steel and the nature of the oil or grease which has been applied to it during fabrication, but, in general, it is necessary to employ a much higher temperature (600 deg. C. or 1,110 deg. F., upwards) than is required to remove obvious greasiness from the surface. The heating should be carried out in a furnace fitted with a pyrometer, and when the correct temperature for a particular batch of material has been found by experiment, it should be closely adhered to; haphazard heating of the articles with a blow-lamp is likely to be unsatisfactory.

The purpose of pickling is to remove scale, rust, and dirt from the surface of the steel, and thus provide a clean surface for tinning. Sulphuric acid does not work efficiently as a pickling bath unless heated to a temperature of about 70 deg. C. (160 deg. F.), but at this temperature its action is more rapid than that of cold hydrochloric acid. A suitable concentration is about 5 per cent. by volume of the concentrated commercial acid, and this will usually pickle steel in about five minutes at 70 deg. to 80 deg. C. (160 deg. to 175 deg. F.). Sulphuric-acid pickling solutions are generally contained in lead-lined vats. There is usually some delay after pickling before articles are required by the tinners, and it is necessary to store them in such a way that they do not rust. The usual method adopted is to keep them immersed in a vat of water which is slightly acidified with hydrochloric acid. The pickled articles are washed, particularly if pickling has been carried out in sulphuric acid, and are immersed in this vat with the minimum delay. They are left there until required for tinning, when they are taken out one at a time, and at once dipped in flux solution and tinned.

Fluxes are used in hot-tinning in two different ways. A solution of a flux in water is used for dipping articles before they are immersed in the molten tin, and a layer of molten flux is generally used as a cover for the tin bath, in order to keep its surface free from oxidation. The flux generally used as a preliminary dip is an aqueous solution of zinc chloride. As the article, wet with flux, is immersed in the tin bath, the surplus water boils off and the zinc chloride melts. The molten salt reacts with the surface of the metal being tinned, and removes films of oxide so that it is perfectly clean at the moment when it comes into contact with the tin.

The flux used as a covering layer on the top of the tinning bath is of the same type as that used as a preliminary dip. It is most convenient to employ the flux in solid form (zinc chloride with 10 per cent. of ammonium chloride) for this purpose, allowing it to melt before tinning is commenced. It is also possible to use the solution by pouring it on carefully and allowing the water to boil off, but this is not recommended, since it pollutes the atmosphere of the tinning shop with acid fumes and a fine spray of flux.

Tinning may be carried out with either one or two pots of tin, according to the quality of finish required. For the best results two pots are used, the first being covered with a layer of molten flux and the second with tallow or palm oil. When only one pot is used, it is always covered with flux. The advantages of using two pots are that the tin in the second may be kept free from iron contamination, and that any flux adhering to the articles on withdrawal from the first bath is removed by the second dipping. In this way a smoother and cleaner finish is obtained. The tallow or palm oil on the second pot keeps the surface of the tin clean and free from dross, and any grease sticking to the articles can easily be cleaned off. Moreover, the presence of slight greasiness on the surface of the tinned articles assists in preserving their bright finish during storage, and in preventing rusting.

The articles are taken one at a time from the cold water storage vat, dipped into flux and immersed in the first tin bath, which is covered with about ½ in. of molten flux. Care is taken not to immerse them too rapidly, since the sudden evaporation of the water would cause splashes of flux and tin to be blown out of the bath. On the other hand, the rate of immersion should not be very slow, as it is desirable that the surface of the article should still be wet as it comes into contact with the molten flux. The time of immersion should be sufficient to allow the article to reach the temperature of the molten tin. This naturally depends upon its thickness, and varies from a second or two for thin sheet metal articles to a minute or more in the case of large articles, such as milk churns. It is desirable that the bulk of tin in the pot should be large in proportion to the weight of the articles being tinned, so that the immersion of the cold steel does not chill the bath seriously. It is very difficult to get a good finish free from adhering dross when working in a pot only just large enough to accommodate the articles to be tinned. In a larger pot manipulation is considerably simplified.

When the article has been immersed for a suitable

* Publication No. 102 of the Tin Research Institute. Abridged.

time it is withdrawn, and, if a second dip is not to be carried out, particular care is taken to avoid adherence of flux or dross. It is found that this is facilitated by pulling the article through the surface of the bath with a jerk. The surplus tin is then drained off. When a second pot is used, the article is immediately transferred to it before solidification of the coating begins. The time of immersion of articles in the second bath may be very brief, since they are already hot and coated with tin from the first bath.

The tinning temperature has an important influence on the extent to which the molten tin drains from the articles after tinning. Adequate draining is necessary since only a limited amount of tin can be held in a uniform layer on the surface, and any excess accumulates in thick streaks or drops towards the lowest point. This surplus tin spoils the appearance and since it is localised it does not increase the durability of the coating as a whole.

In carrying out the tinning operation as described above, the usual working temperatures are about 280 deg. C. (535 deg. F.) for the first pot and 260 deg. C. (500 deg. F.) for the second. With articles made of heavy gauge steel these temperatures are sufficiently high to allow the surplus tin to be drained off before the coating solidifies. With thin sheet steel articles cooling takes place very quickly, and it is not possible to drain off the excess tin during normal air cooling from the temperatures mentioned. Two alternative procedures are available. For articles on which a high-grade finish is required, the two tinning baths are employed as already described, and the temperature of the second is kept at about 250 deg. C. (480 deg. F.). The draining of the surplus tin is then effected in a third pot containing hot grease in the manner described below. The other method, used for cheaper articles, is that known as sal-ammoniac tinning and is also described below.

In sal-ammoniac tinning, one tin bath is used and it is not provided with a cover of flux. The article is prepared for tinning in the usual way and dipped in a zinc-chloride flux solution. A little powdered ammonium chloride (sal-ammoniac) is then sprinkled on the surface of the bath, and the article is dipped while the ammonium-chloride fumes are still being given off. The volatilisation of the chloride keeps the surface of the tin free from oxidation, and the article may be withdrawn with a clean finish. Articles tinned in this way are rather less liable to the yellow coloration caused by high tinning temperatures than those tinned with zinc chloride alone, or with tallow. The method is only suitable for high temperatures of tinning, since the volatilisation of the ammonium chloride is not sufficiently rapid below 300 deg. C. (570 deg. F.) to keep the surface of the tin bath clean. It works particularly well at about 300 deg. to 325 deg. C. (570 deg. to 620 deg. F.). While this method of tinning is convenient for some purposes, the results are not, in general, as durable as those obtained by the methods involving the use of grease. There is greater liability to rusting or discoloration, which is probably due, in part, to traces of ammonium chloride condensing on the articles as they are withdrawn from the bath. Another factor is the absence of the grease film which is always present on articles tinned with a cover o tallow or palm oil and which assists in preventing corrosion or discoloration.

Grease-tinning is an old process, in which, in its original form, molten grease takes the place of fluxes such as zinc chloride. In this way the risk of the presence of corrosive flux spots on the finished articles is avoided, and the articles may be stored for a considerable time without rusting or discoloration. A further advantage is that, owing to the absence of chloride fluxes, the accumulation of tin-iron compound in the tin bath is, to a large extent, avoided. In this form the process is slow, since grease alone is not very effective as a flux in the first or rough-tinning operation, and the steel has to be immersed for a relatively long time before it is properly tinned. In order to increase the output, it is common practice to shorten the rough-tinning operation by using a zinc-chloride flux in conjunction with the grease. Apart from this modification the new and old forms of the process do not differ materially.

Articles intended for grease-tinning are degreased, pickled, and washed in the manner already described. The tinning plant consists of five pots, namely, (1) grease pot; (2) rough-tinning pot; (3) finishing tin pot; (4) grease-pot for draining off surplus tin; and (5) listing tin pot for removing drips. The articles are taken from the water vat and immersed in the first grease pot, which is maintained at about 250 deg. C. (480 deg. F.). They are allowed to remain here for some time, until the steel has reached the temperature of the grease, and the latter has expelled all traces of moisture from the surface and removed any slight film of oxide which may be present. This requires from five to twenty minutes for sheet-metal articles, depending upon the thickness of the steel. The articles are then transferred directly to the first or rough-tinning pot, which contains tin at about 280 deg. C. (540 deg. F.), and is covered with a layer of grease. Here again, an immersion of 10 minutes or more is usually necessary, and generally a number of articles are tinned at the same time.

When an article is removed from the rough-tinning pot, it is lightly brushed over with a soft hemp brush, dipped in melted grease, to remove any dross, etc., and placed in the second tin pot. This is covered with a thin layer of grease, and is maintained at 250 deg. to 260 deg. C. (480 deg. to 500 deg. F.). The article is dipped only momentarily before being transferred to the grease draining pot for removal of the surplus tin. A suitable time of immersion in the draining pot is from 5 to 10 seconds, depending upon the size and shape of the article, and the temperature is maintained at 245 deg. to 250 deg. C. (470 deg. to

FIG. 3. STREAKINESS OR DE-WETTING IN TIN COATING.

FIG. 4. GRITTINESS DUE TO TIN-IRON COMPOUND.

480 deg. F.). On removal from the draining pot, the article has a drip of tin at the lowest point, and this is taken off by bringing it carefully into contact with the surface of the tin in the listing pot; this is a shallow pot, containing molten tin at about 250 deg. C. (480 deg. F.). Solidification of the coating occurs quite rapidly, on account of the relatively low temperature of the final draining pot, and with sheet-metal articles of average thickness the brightest finish is obtained by ordinary air cooling.

The most important source of contamination of tinning baths by iron is the reaction of the iron or steel being tinned with the zinc-chloride flux which is generally employed. This reaction is usually considered to proceed in the following manner: A zinc-chloride flux containing water is hydrolysed to some extent to form hydrochloric acid. The acid attacks the iron, effecting the desired cleaning of its surface, and forming ferrous chloride, which, in solution in the zinc chloride, reacts with the molten tin to give stannous chloride and free iron. Since the iron formed in this way is in a finely divided condition, it is immediately acted upon by the tin to give the compound $FeSn_2$. This source of contamination is minimised by keeping the acidity and iron content of the flux as low as possible. The flux should be kept in an earthenware vessel and not in an iron vat.

The tin-iron compound is practically insoluble in molten tin at tinning temperatures, so that if more than a very small amount of iron is present in the tin bath it exists in the form of minute solid particles of the compound. The latter has approximately the same specific gravity as tin, so that it is difficult to remove by settling. At ordinary tinning temperatures it is very slightly denser than the molten tin, and on prolonged standing it tends to accumulate at the bottom. When the bath is being used, however, the agitation caused by the immersion and withdrawal of articles prevents any settling, and much of the compound is distributed throughout the tin. A certain amount is often found floating at the surface, forming patches of a pasty consistency, which tend to stick to articles when they are removed from the pot. The effect is to give the tinned articles a gritty appearance as illustrated in Fig. 4.

The removal of iron from hot-tinning baths must be carried out at frequent intervals, and the usual procedure is based on the fact that if particles of the compound come into contact with particles or films of tin oxide, they are retained by it, and form a scum or dross which floats on the tin bath and can be removed effectively by skimming. In the method which is generally used, raw potatoes or pieces of green wood are immersed in the bath. This causes a vigorous agitation or "boiling" of the tin, and the particles of tin-iron compound suspended in it are circulated rapidly. As they come to the surface, they become entangled in the oxide film formed there by contact with air, and remain floating. After a short time, a large proportion of the particles of compound are brought to the surface in this way, and a heavy pasty dross is formed, which may be skimmed off easily.

Tinning of Copper and Copper Alloys.—The tinning of copper by hot-dipping follows, in general, the procedure already outlined for steel. On account of the reaction between copper and tin, however, the tinning bath and the coatings produced from it gradually become richer in copper, and this eventually causes the coatings to be rough. The most important rules in the tinning of copper are therefore to keep the temperature of the bath as low as possible and the time of dipping as short as possible. A good tinning temperature from the point of view of minimising copper contamination is 250 deg. C. (480 deg. F.), but for many purposes a somewhat higher temperature, of 270 deg. to 280 deg. C. (520 deg. to 545 deg. F.), must be used in order to allow time for adequate draining of the surplus tin before solidification of the coating.

The tinning of brass is generally carried out in the same way as the tinning of copper, and the same care must be taken to use the lowest temperature and shortest time of dipping consistent with convenient working. A further complication is introduced in the case of brass by the fact that the tin bath picks up zinc as well as copper during use. The presence of zinc causes the tin to oxidise and dross very readily, forming a whitish skin which adheres to the articles as they are withdrawn from the bath. It also makes the tin less fluid and therefore more difficult to drain from the tinned articles. For these reasons there is considerable difficulty in obtaining as good a finish on hot-tinned brass as on hot-tinned copper, and there is a particularly strong case for tinning brass by electrodeposition.

Tin bronzes are quite easy to tin by hot-dipping, and the procedure does not differ appreciably from that used for copper. Aluminium bronze, and the other special copper alloys containing aluminium are not readily hot-tinned unless they are first plated with a thick layer of copper (0·001 in. to 0·003 in.) by electro-deposition. For this reason, electro-tinning is generally preferred, as it may be carried out without any special difficulty.

Tinning by Wiping.—It is occasionally desired to tin vessels on the inside surface only. This can be effected by means of the wiping process, which is also used for the tinning all over of articles which are too large to be accommodated in the dipping pot available. The method may be employed for copper and its alloys and for steel but, on the whole, is more used for the former class of materials.

Cleaning and pickling are carried out by the usual methods, already described, and the articles are then washed and dried as quickly as possible to avoid oxidation or corrosion. This is particularly important in the case of steel, which rusts readily after pickling. The articles are then heated over a fire or gas burners to a temperature somewhat above the melting point of tin. Finely-powdered ammonium chloride is sprinkled on to act as a flux, and tin is applied by

rubbing the heated surface with a stick of tin. In some instances it is found convenient to pour a little molten tin into the vessel, pouring out the surplus into the next vessel when the wiping is finished; this is the procedure adopted with iron saucepans. The tin is wiped round, using more flux as required, until a smooth, continuous coating is obtained. The wiper may consist of a cork mounted on a stick (for small vessels), rag, tow, steel wool, etc. Since the finished coating is usually a little dirty from dross and burnt residues left by the charring of the wiper, the articles are often scoured afterwards with silver sand.

From the above description, it is evident that the success of the operation depends largely upon the skill of the tinner. Temperatures must be judged entirely by inspection, and the work must be carried out quickly. Speed is necessary in order to avoid oxidation of the heated article before the tin is applied, and to prevent undue formation of intermetallic compounds during the wiping.

A modification of the same method is employed for the tinning of copper sheets on one side only. The sheets are dipped in acid, washed and dried, and then whitewashed on the side which is not to be tinned. After the whitewash has dried, the sheets are tinned one at a time on a sloping table adjoining a tinning pot. This table is arranged so that any surplus tin running off the sheets is returned to the pot, and it is heated by the flue from the tinning pot which runs beneath it. The sheet is rubbed over with a mop dipped in flux solution and tin is then poured over it by means of a ladle until it is completely coated. It is then wiped as already described and, if necessary, finished by scouring or polishing.

We are indebted to the Tin Research Institute for the loan of the photographs from which our illustrations have been prepared.

WELDED WATER MAIN IN BURMA.

An interesting illustration of the growing self-sufficiency of India from the point of view of engineering construction lies in the recent fabrication by welding of 43 miles of water main 4 ft. 10 in. in diameter for the City of Rangoon, the steel plate having been rolled by Messrs. The Tata Iron and Steel Company, Limited, at Jamshedpur, and shipped across to Rangoon, where the fabrication was effected by Messrs. Braithwaite-Burn and Jessop Construction Company, Limited. The main was made in lengths of 25 ft., each length of pipe consisting of three plates in the circumference, the plates as rolled being 62 in. wide by $\frac{7}{16}$ in. thick. After the plates had been bent to one-third of a circle, each set of three was assembled in six rigid rings spaced equally along the length of the pipe and supported on rollers. An automatic carbon-arc welding head, of the "Electronic Tornado" type, made by Messrs. Lincoln Electric Company, Limited, Welwyn Garden City, Herts, and mounted on a small carriage, was then run along the longitudinal seam at the bottom of the assembly and the pipe subsequently rotated for the welding of the two remaining seams in the same position. The seams were butt-welded and the current supply to the head, obtained from a standard Lincoln "Shield-Arc" generating set, was effected through a trailing cable.

The seams were not completely welded from the inside only, a second run on the external surface of the pipe being required to complete them. Obviously, the carrying rings would have been in the way of the traverse of the welding head for this second operation, but the structures were sufficiently rigid after the first operation to enable them to be removed, for which purpose the rings were made in segments capable of being bolted together rigidly. To prevent distortion of the pipes, however, they were supported at intervals inside by a number of three-armed spiders. The arms were furnished at the ends with segmental angle bars to give adequate support to the interior of the pipe, and each arm was provided with a sleeve having a right- and left-hand thread and a cross-bar for turning. The spiders could then be adjusted, with the arms in line, on the circumference, with the three longitudinal seams, so that circularity was maintained. The seams were then welded on the outside of the pipe by an automatic carbon-arc welding head in the same manner as the internal welding had been effected. The welding head in this operation was traversed along the top of the pipe, the seam being dealt with being in this position and the pipe being rotated for the other two seams. The pipe was supported on rollers mounted in cast-iron pedestals. The fabrication of this water main necessitated the employment of 500 men, all of whom, with the exception of ten, were native workers. No particulars are available of the time taken in fabricating the pipes, but it is notable that, by adopting welding for construction, the contract was completed six months before the scheduled time.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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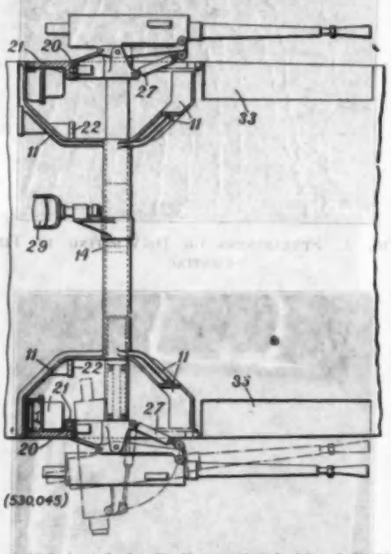
GUNS AND EXPLOSIVES.

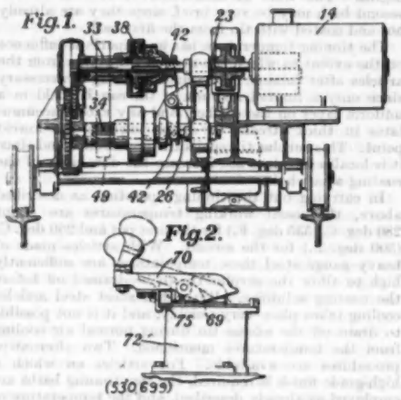
530,045. Retractable Gun Mounting. The Fairey Aviation Company, Limited, of Hayes, and J. Hetherington, of West Ealing. (4 *Figs.*) November 17, 1938.—The guns are designed for mounting in an aircraft. Two bowl-like spiders 11, each consisting of three arms, carry a circular rack and are mounted at the top and bottom of the fuselage. Between the spiders is mounted a hydraulic cylinder 14, having opposed rams at its ends. An annular turntable carrying an electric motor rotates on each spider, the motor driving a pinion meshing with the circular rack. Each ram mounts a gun cradle,



on which is a hydraulically-operated locking bolt 20, which registers with either of two apertured lugs, the lug 21 being carried by the turntable and the lug 22 by the spider. The bolt thus locks the cradle to the turntable or to the spider when the guns are in their firing or stowed positions, respectively. The guns are mounted in pairs on each cradle on trunnions, and are controlled by handles 29, the handles for the two groups being mounted side by side on the main hydraulic cylinder. In operation, if the guns of a group are in their stowed positions, the locking bolt 20 is first withdrawn, the associated ram brings the group of guns to their firing position, and the locking bolt 20 locks the guns in this position. The electric motor can then traverse the guns in azimuth, and the hydraulic elevating ram 27 elevates or depresses them. The guns are stowed in recesses 33 in the fuselage. (*Accepted December 5, 1940.*)

LIFTING AND HAULING APPLIANCES.

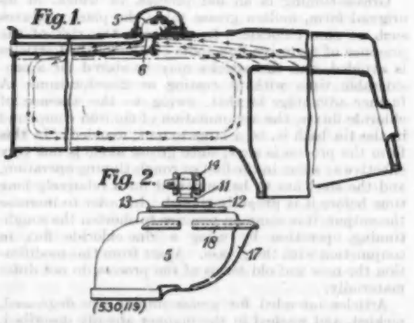
530,699. Crane. Stringer and Son (Cradley Heath), Limited, of Cradley Heath, and J. W. Powell, of Cradley Heath. (8 *Figs.*) June 15, 1939.—The illustration shows a foundry crane of known type. Such cranes are frequently required to hoist at very slow speeds, such as when handling moulding boxes. The motor 14 operating the winding drum is connected by a plain flanged coupling to a coaxial driving shaft 23. This shaft is geared through an intermediate shaft to a lower driving shaft 26, the gear ratio allowing the lower shaft 26 to make three revolutions for every 40 revolutions of the upper shaft 23. On the shafts 23, 26 are freely mounted driving pinions 33, 34, respectively, each of which can be clutched to its shaft. Each clutch consists of a sleeve keyed to the respective shaft and having a circumferential flange 38 which engages one face of an annular clutch plate secured within the rim of a coaxial cup fixed to the adjacent driving gear. The other face of the clutch plate is engaged by a pressure plate sliding on the sleeve. The clutch operating gear consists of a grooved collar 42 which slides on the shaft 23 (or 26) and acts on the pressure plate through toggle levers. The two grooved collars 42 are engaged by pins at opposite



ends of a rocking lever. A gear wheel 49 (shown in chain-dotted lines) meshes simultaneously with the two driving pinions, one of which is always freely rotatable, and its shaft is geared to the winding drum shaft. Normally, the winding drum is rotated at the lower of the two speeds since the clutch mechanism is biased to keep the clutch on the lower driving shaft 26 engaged. The clutch is operated by a hydraulic Thrustor unit. To ensure against a speed change during operation of the motor, the clutch mechanism is interlocked with the motor controller to prevent its movement until the motor has been shut off. The upper end of the controller spindle (Fig. 2) carries a bracket 69 on which the operating handle recks, the handle being spring-loaded into the raised position. Depression of the handle 70 closes a switch within the housing 72, which sets in motion the motor of the Thrustor. On the switch housing is a guard disc 75 which is engaged by a hook on the handle 70. A notch in the guard disc opposite the "off" position of the controller allows the handle to be depressed or raised only when the motor is switched off. (*Accepted December 18, 1940.*)

STEAM ENGINES, BOILERS, ETC.

530,119. Steam Regulator. Meboe, Limited, of Westminster, and A. R. Craven, of Westminster. (4 *Figs.*) June 3, 1939.—Locomotive regulator valves are liable to flooding owing to their proximity to the water, and the invention is a valve which prevents water and foam from gaining access to the inlet when the boiler is priming. With the regulator valve open and the locomotive running and steaming hard, the great heat of the firebox causes ebullition of the water and a rapid flow



towards the front end of the boiler, as shown by the arrows. This ebullition and rapid flow impinges on the regulator and builds up against the valve body 5, and, with normal forms of valve, water and foam gain access to the steam chests. In the valve shown, steam is admitted to the steam chests from the top of the valve body 5, when three concentric valves 11, 12 and 13 are lifted by a yoke 14. The valve body 5 is streamlined to a prow-like form at 17, and this streamlined shape, which is also extended down over the elbow 6, divides the flow of water and directs it downwards. A deflector plate 18, concave on the underside, catches any rising water and deflects it downwards from its rim. (*Accepted December 5, 1940.*)